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Technical Memorandum 14-65

GROUP BEHAVIOR IN CONFINEMENT:

REVIEW AND ANNOTATED BIBLIOGRAPHY

Alfreda R. Honigfeld

October 1965
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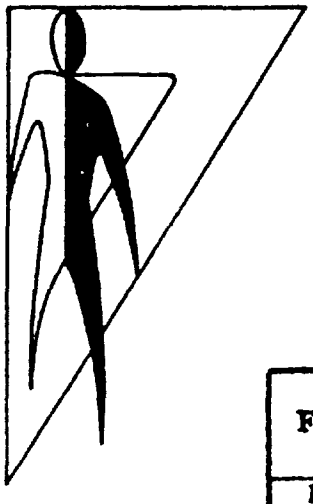
HUMAN ENGINEERING LABORATORIES



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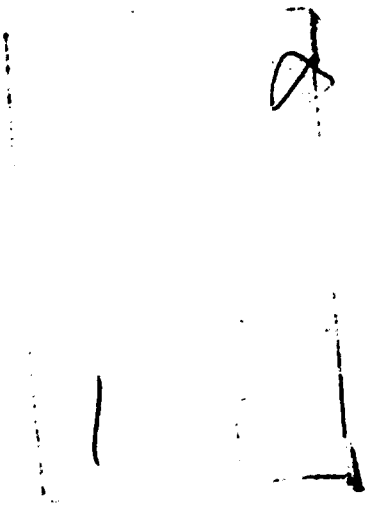

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ABSTRACT

Field and laboratory confinement studies were reviewed to evaluate existing information and to identify areas where future research is needed.

The studies reviewed deal with confining two or more people in a restricted space for a prolonged period of time: particular attention was devoted to how such conditions degrade performance.

Few of the studies bear on the Army's chief interest in confinement: how men will perform during and after prolonged confinement in armored vehicles.

The review concludes by recommending ways to make future studies of confinement more directly relevant to the Army's interest.

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INTRODUCTION

Because of requirements for greater mobility on the battlefield and for operating under threat of nuclear attack or in areas of radiation fallout, troops may have to live and fight in armored vehicles for long periods of time. Since soldiers may spend from eight to 48 or more hours confined in these vehicles, the Army needs to know as much as possible about how confinement affects performance. A survey of both field and laboratory confinement studies will help in evaluating information that already exists and in identifying areas where major research efforts will be needed in the future.

Various problems are inherent in situations where people must remain in a limited space for a prolonged period of time -- the stresses of physical discomfort, the sanitation inadequacies, the need for activity, the need for controlling the atmosphere, the tensions of enforced prolonged exposure to other personnel, the need to perform tasks. Such problems have important implications for personnel training and hardware design. It is the analysis of these problems, the study and observation of the factors which may degrade performance during confinement, which are of concern to the Army.

The confinement conditions that affect performance can be divided into two major categories: (a) those operative during confinement, as during long periods of confinement in a buttoned-up tank; and (b) those operative after release from confinement, as after release from an armored personnel carrier. The questions most relevant to Army problems are:

a. Can personnel perform efficiently when they are confined?

b. Will they continue performing efficiently when they are confined for long periods?

c. Will they perform effectively when they are released from confinement?

d. What are the best ways to measure performance during and after confinement?

If performance declines during confinement, the types of performance that are affected most must be considered both in training men and in designing equipment. Warning signals, for example, can be either visual or auditory, but if one sense modality shows more degradation than another, the signals should be directed to the sense which is affected less.

In analyzing crew performance under confining conditions, we must distinguish among the terms "confinement," "sensory deprivation," and "isolation," which are often used rather indiscriminately. Broadly, confinement is any situation which restricts an individual's physical movements and keeps him within a certain limited space. Sensory deprivation means reducing or curtailing all stimuli to the senses: sight, hearing, smell, taste, and kinesthesia. Isolation is separation from society -- either separating an individual from a group, or separating one group from another group.

It is sometimes hard to distinguish these terms clearly in use, because each of the three types of experience partakes in some degree of the other two. Sensory deprivation, for example, involves confinement and isolation. In a sensory-deprivation study, the subject might lie still, with his limbs encased in tubes; or he might be submerged in water and asked not to move. Because his movements are restricted, he is confined. During sensory-deprivation studies, the individual is removed from contact with other people, so he is also isolated.

Confinement includes limiting some sensory inputs. Restraining physical activities limits kinesthetic inputs and deprives that sense somewhat. Confinement also usually involves forcing personnel to live closely with others.

Isolation may take different forms: an individual may be placed in an area where there are no other humans, or a group may be isolated from other human groups. In a laboratory the only way to isolate a subject is to confine him to a place where both isolation and confinement deprive him of a certain amount of sensory stimulation. Thus merely attempting to define the terms themselves demonstrates the difficulty of studying confinement, sensory deprivation, or isolation separately.

DISCUSSION

Although there is much information about people subjected to sensory and perceptual deprivation, this review includes only the landmark studies. Deprivation studies are not directly applicable to Army problems; in armored vehicles the senses are more often bombarded by the jogging and swaying of a mobile vehicle, the sound of motors, the hum of generators, talking, various odors, temperature extremes, etc. While this review focuses on studies of groups (two or more people) confined to small spaces for prolonged periods of time, the critical work on sensory deprivation has been included because some types of confinement do involve deprivation.

Of the extensive research on sensory deprivation, this review surveys only the work of Bexton et al. (9), Freedman & Greenblatt (20), Wheaton (62), and Zubek et al. (63). The methods these investigators used are basic to many sensory deprivation studies. Here, subjects are cut off from external stimuli: the body is encased in restrictive clothing, tubes, or water; subjects wear either black goggles or translucent glasses that permit only diffuse, homogeneous lighting; auditory stimulation is standardized by presenting "white noise" (a steady, random mixture of many frequencies); subjects are instructed to move as little as possible over extended periods of time. The effects of minimal stimulation are measured with behavioral observations, psychiatric interviews, psychological tests, and psychophysiological measures such as electroencephalograms, electrocardiograms, and galvanic skin responses. Most of these procedures are used both before and after imposing experimental conditions, but behavior can also be observed as the experiment progresses.

These sensory-deprivation studies make several points which should be considered in discussing confinement:

a. Sensory deprivation and/or isolation produce a characteristic progression of symptoms which depart from individual behavior norms. These symptoms, which appear to be directly related to the intensity, complexity, and duration of the stress, may be modified by:

(1) Types of isolation imposed.

(2) Additional complicating stresses (such as hunger, thirst, physical discomfort, injury or illness).

(3) How "stressful" a particular combination of stresses is for the particular individual.

(4) Individual ability to function well within an isolated group.

(5) Previous experience in similar stress situations.

b. Symptoms usually include degraded thought organization, time distortions, intellectual inefficiency, bizarre thoughts, exaggerated emotional reactions, imagery or hallucinations, headaches, mild nausea, fatigue, and impaired dexterity, kinesthetic acuity, and color discrimination.

Some of the symptoms these studies elicited would probably also occur in some confinement studies, and they would probably be modified by any of the conditions mentioned above. It has not been demonstrated, however, that all types of confinement necessarily degrade thought organization or produce hallucinations.

The methods used in confinement studies vary widely. Both field and laboratory studies have been conducted.

Ormiston (49) attempted to develop criteria for methodology in confinement studies. Each of 34 male volunteer undergraduates was confined individually for eight hours in a lighted 5' x 8' cubicle. A control group of 26 men was not confined. Ormiston measured how confinement affected four visual illusions -- phi phenomenon, autokinetic phenomenon, Necker reversible cube, and spiral after-effect. Only one of these illusions showed any effect: with longer confinements, the spiral after-effect lasted longer.

He also correlated performance with scores on a battery of personality tests -- Edwards Personal Preference Schedule, Minnesota Multiphasic Personality Inventory, Allport-Vernon-Lindzey Study of Values, Time Orientation Survey, and Perceptual Generalization Test -- but none of these scores was significantly related to performance. In the psychomotor area, Ormiston found that short-term confinement had little effect on simple tracking. A more complex task combined constant monitoring, which is a good measure of boredom, with dual compensatory tracking, which unfortunately seemed to relieve boredom. Time estimation seemed little affected by confinement and, therefore, a poor way to measure confinement degradations.

This study, then, had little success in finding criteria for measuring confinement performance. No one has attempted to extrapolate the results of these laboratory findings to a field situation. When subjects are aware of their roles as subjects, as they often are in laboratories, results may not be the same as in an operational setting. Laboratory subjects become sophisticated; they may develop mental sets from their instructions, they may try to conform to the experimenter's expectations, and they tend to dramatize. In an operational field study these variables are much less important.

Group Behavior Under Stress

The relation of personnel interactions to stresses is an important aspect of confinement. Anecdotal reports show that people who originally enjoyed each other's company may, after prolonged exposure to one another, become extremely hostile and antagonistic (16, 22).

In an operational study, Kinsey (41) confined 23 men together for two months aboard a submarine. He evaluated group behavior with interviews, daily diaries, casual observation, and a structured questionnaire. His principal conclusion parallels that of many similar studies -- well-adjusted individuals cope with confinement better than poorly adjusted people.

Lanzetta et al. (44) imposed threat on groups of three students doing a highly structured task in the laboratory. Threatened groups attacked task problems less forcefully, assertively, and actively than unthreatened groups. Threatened groups were less efficient and less adaptable. Under threat, group effectiveness became poorer and more variable.

Lanzetta (43) did another laboratory study, in which groups of four people worked on a group task. As stress increased, the group members disagreed, argued, and quarreled less, while they collaborated, mediated, and cooperated more. Both the observers and participants saw the groups as less competitive, more cooperative, and more friendly under increased stress. But Lanzetta also asserts that the majority of stress studies show reactions of aggression, withdrawal, escape behavior, and regression.

The results from the above two laboratory studies are directly opposed to findings when groups are confined under high threat in real-life conditions (16, 22). Because the results of laboratory studies and actual field threat situations do disagree, it is difficult to predict how a group of men might react when confined in an armored vehicle in a high-threat field condition.

Ruff et al. (54) studied confinement in a laboratory situation by placing five-man groups in a small compartment for five days. They used the following measures:

a. Direct observation, including diaries, tape recordings, and motion pictures.

b. Bales Interaction Analysis.

c. Ranking scales to determine attitudes toward other crew members.

d. Interpersonal projection test where photographs were arranged according to their appearance of being "relaxed," "upset," etc.

e. Draw-a-Group Test.

f. Psychiatric examinations by two psychiatrists before and after experiment.

g. Personality tests:

(1) Rorschach

(2) Thematic Apperception Test

(3) Minnesota Multiphasic Personality Inventory

(4) Blacky Test

(5) Draw-a-Person Test

(6) Sentence Completion Test

h. Intelligence tests.

i. Performance tests of vigilance, counting ability, and reaction time.

j. Bender-Gestalt Test.

k. Electroencephalogram.

l. Electrocardiogram.

m. Galvanic skin response.

n. Biochemical measures:

(1) Urinary pepsinogen

(2) Adrenal steroids

(3) Sodium, chloride, potassium

(4) Hippuric acid

o. Recent flight physical examinations.

p. Hematology.

q. Urinalysis.

After careful study of all these data, only three definite conclusions emerged: that different groups behave differently; that there is a great increase in interest in food; and that hostile feelings aroused by fellow crew members were not expressed overtly but in sarcasm, in comments in diaries, and on projective tests.

Hagen (23), using some of the same psychological measures, got similar results. Again, hostility developed between two men who spent 30 days in a space-capsule simulator, but adaptive mechanisms prevented overt conflict, and the task was completed effectively.

In a simulated shelter study, Altman et al.(7) made auditory and visual observations of 30 people for one to two weeks. The observers found that agitation and tension were greatest just after the subjects entered the shelter and just before they left it. Mild depression was common toward the middle of the stay. These effects seemed minimized when a trained shelter manager was present. Also, each individual's adjustment to the shelter seemed to reflect his pre-shelter adjustment fairly directly.

Flinn et al. (19) reported that two subjects who were confined in a simulated flight chamber for 14 to 30 days showed only covert antagonisms, which they displaced toward monitoring personnel outside the chamber. The men's post-flight debriefings and their diaries confirmed these antagonisms. The subjects refrained from any behavior which might have disrupted their relationship, and they were able to continue working together effectively for the duration of the study.

Other studies included in this section have found similar results. In view of the many various methods for exploring how stress affects confined groups, the findings seem fairly consistent. They can be summed up as follows:

a. When people are motivated highly, they can maintain effective working relationships during confinement.

b. People in confinement will undoubtedly develop feelings of resentment, but they will displace most of their negative feelings and direct them either toward personnel outside the confined situation or to objects. They will seldom express anger directly, although they may reveal it as sarcasm, in humor, or in comments in personal diaries. These adaptive mechanisms tend to prevent overt conflict, maintaining an atmosphere in which people can work toward completing their mission.

c. As stress increases, individuals seem to make more effort to control interpersonal tensions. Here, they substituted positive, group-oriented behaviors for negative, individually oriented behaviors. Members of a group become less competitive and more cooperative. In the face of external stress and increasing anxiety, group members perceive the group as a source of security and attempt to prevent rejection by cooperating more.

Of course, the above findings do not apply in all types of confinement situations nor under all stress conditions, but hold only for the specific conditions being evaluated.

Task Performance

What the Army most needs to know about confinement is how confinement affects task performance. Can soldiers perform efficiently during prolonged confinement in an armored vehicle? And can they perform effectively after they are released from prolonged confinement? The two main bodies of information on these questions have been developed by the Naval Air Engineering Center and by the Army's Human Engineering Laboratories.

The Naval Air Engineering Center has completed two series of studies, the first consisting of four reports and the second of six reports; only pertinent reports are annotated and discussed here. These studies attempted to determine the environmental requirements of sealed cabins for space and orbital flight; to evaluate a closed-loop solid-chemical rebreathing system; and to assess the psychological and physiological effects of prolonged confinement on human subjects. It is this last assessment which is of interest here.

The Naval Air Engineering Center used the following tasks to measure performance:

a. Keeping three dial pointers at their null points.

b. Reacting to visual warning indicators.

c. Attending to details of a spoken prose passage and making inferences beyond the material presented.

d. Doing arithmetical reasoning.

e. Learning to associate single or multiple alternatives in an alternatives test.

f. Finding multiple solutions in a test of intellectual flexibility.

g. Discriminating weights.

h. Estimating time at 90-second time intervals.

Six men were confined for seven days in the simulated space-cabin environment (simulated altitude of 10,000 feet, with an oxygen concentration equivalent to 55 percent at sea level). They worked in pairs, alternating four hours on duty and eight hours off duty, throughout the study. Each member of the pair tested, scored, and timed the other's performance.

While this environment in no way duplicates the armored vehicle environment, the long-term confinement and some of the performance measures do yield applicable information.

The main findings of these studies are:

a. The subjects' intellectual functions did not deteriorate over a seven-day period, even though environmental conditions were not optimum.

b. Subjects performed as well on the seventh day of confinement as on the first day with complex tasks which seemed to have special interest to them.

c. Variable performance on psychomotor tasks probably reflects boredom. Apparently any deviation from optimum conditions has more and more effect as confinement time increases.

Hicks (29 through 37) did extensive research to determine how long troops can tolerate the adverse environmental conditions imposed by long periods of confinement in armored personnel carriers (APCs). These studies come closest to answering some of the Army's questions on confinement, but they do not provide complete information on the confinement problem. Hicks used a total of 277 enlisted men. They were subjected to varying periods of confinement ranging from four to 24 hours in both moving and standing vehicles, with open and closed hatches. Subjects took tests of combat-relevant skills both before and after confinement. These tests included measures of stamina (220-yard running course), response time (Stoelting Selective Reaction-Time test), gross motor coordination (obstructed run, grenade throwing, 220-yard run, obstructed run), arm steadiness (Stoelting Hand-Steadiness test), and equilibrium and eye-arm coordination (rifle firing and grenade throwing). However, the subjects did not perform any tasks while they were actually confined. Thus a large area of information remains unknown -- how well can men perform combat-relevant tasks while they are confined in armored vehicles.

Hicks' major conclusions were:

a. Most subjects showed significant losses in all kinds of performance tested, after all confinement periods.

b. Highly motivated subjects show less performance decrement than subjects who are not highly motivated.

c. Subjects adapt progressively to repeated periods of confinement, showing smaller performance losses after each successive confinement.

d. Confinement has relatively transient effects on performance of the tasks studied.

e. Confinement's detrimental effects on performance may be offset by repeated practice at the tasks and by repeated exposure to the confinement situation before actual field deployment.

Ormiston and Finkelstein (50) confined subjects in a simulated space capsule for 48 hours, while measuring their performance on a wide variety of tasks: arithmetic memory for digits, confusion sentences, nonsense syllables, verbal analogies, same-opposite word meanings, logical reasoning, discrimination of embedded figures, aerial reconnaissance, and dual-compensatory tracking. They found that 48 hours of close confinement had no appreciable effect on tests of intellectual functioning. Confined subjects appear to maintain their perceptual speed and accuracy, as well as their ability to discriminate forms, and confinement does not seem to affect how well men monitor warning lights. While some of these tasks are valid tests of intellectual functioning, it is difficult to tell whether men use these same intellectual functions in performing their assigned tasks in an armored vehicle.

In studying the performance of two men confined in a low-pressure atmosphere of pure oxygen for 120 hours, McGrath et al. (45) used a vigilance task, a memory-span test, an attention test, a time-perception task, and an object-identification task. In this exotic atmosphere, detection performance and attention deteriorated, while memory span was unaffected. The time-perception and object-identification data were not significant. While men might perform such tasks in an armored vehicle, these results are not directly applicable, because the special atmospheric conditions were modeled on spacecraft, rather than armored vehicles.

Weybrew (60) placed a group of subjects in a room where they viewed a pointer moving around a circle once a minute, much like a clock's second hand. Each subject was to press a button every time the pointer moved 90 degrees of arc -- or four times per minute. The experimental group pressed the button every 15 seconds, but they were not told whether or not it was on target. The control group got feedback information about whether they responded correctly. Weybrew found that environmental feedback was important in maintaining vigilance during this repetitious activity.

In the major operational part of the Weybrew study on submarine confinement, 23 men were confined in a sealed submarine for 50 days. He found that, although psychomotor or manipulative ability changed little, other variables did show significant changes:

a. Significantly less personal motivation and group morale.

b. Increased interpersonal irritability.

c. Increased muscular tension, with concomitant sleeping difficulties.

The Aerospace Medical Research Laboratory has done considerable work on optimal work-rest cycles. In this group of studies, the performance measures included tasks such as mental computation, pattern discrimination, monitoring, vigilance, information exchange, and cooperation among members of five-man crews. The men were tested for four consecutive days, after three days of training. In the initial study (5), Alluisi and his associates attempted to establish reliabilities for the above measures. They found that the measures were reliable enough to be applied in further studies. Unfortunately, the validity of these variables as job performance measures has not been established.

In the second study (6), six subjects were confined for 15 days in a simulated space compartment, under a four-hour-on-duty, two-hour-off-duty (4-2) schedule. Also, two five-man crews were confined for 30 days on a four-hour-on-duty, four-hour-off-duty (4-4) schedule. Al. were tested on the Alluisi battery of tests. The results showed that, while highly motivated subjects can perform acceptably for two weeks to a month on a 4-2 schedule, performance on a 4-4 schedule is universally better and probably can be maintained without decrement for 60-90 days.

Adams and Chiles (2) confined one five-man and one six-man crew for 15 days in a simulated space compartment. These crews were tested on a 4-2 schedule with five of the above tasks. Again it was found that highly motivated subjects can work at least two weeks on a 4-2 schedule.

Alluisi et al. (3) tested two five-man crews on a 4-4 schedule for 12 days' confinement in a space compartment, using the same measures as Adams and Chiles. Once more, the 4-4 schedule proved superior to the 4-2 schedule.

A summary of these four studies of different work-rest schedules in confinement reveals that performance is generally better on a 4-4 schedule than on a 4-2 schedule. The stress of losing sleep generally degrades performance more on the 4-2 schedule than on the 4-4 schedule.

Highly motivated men can maintain acceptable performance levels on a 4-2 schedule for at leas' two weeks, and probably for a month. However, all subjects performed better on the 4-4 schedule. The 4-4 schedule can probably be maintained for 60-90 days before performance shows degradation. The 4-4 schedule has more "safety factor," because crew members can work more hours to make up for illness or other lost man-hours by temporarily following a 4-2 schedule if they have to.

Patton (52), confined two subjects in a simulated space capsule for seven days on a 4-4 schedule. In one of his physiological and behavioral measures, the subject had to locate and mark certain designated letters in an array of letters. Both subjects

learned to perform faster during the confinement, but their error-score results were not consistent. Patton concludes that subjects can maintain proficiency in an information-processing task while confined in a small capsule.

Under these same conditions, Patton and Randle (53), evaluated performance on a pattern-discrimination task. The patterns -- three to seven lighted elements in a 6 x 6 matrix of lamps -- were presented at the beginning and end of each 4-4 duty shift. Patton and Randle compared performances from session to session within a shift, between shifts, and over days. Their main finding was that quality of performance improved during the early part of confinement, then declined -- but was maintained at a reasonably high level throughout the seven-day confinement.

The information on task performance and confinement can be summarized as follows:

a. Confined subjects' intellectual performance will not necessarily deteriorate, even though the environmental conditions are not optimum.

b. Confinement has little effect on tasks such as radar monitoring, vigilance, discrimination, problem solving, aerial-reconnaissance perception, rapid and accurate perception, form discrimination, tracking, and time estimation.

c. Confined subjects can perform complex tasks, if they are of particular interest to them, effectively for long periods. Variable performance on psychomotor tasks probably arises from boredom. Thus simple, routine tasks should be supplemented with more complex tasks which require higher-level behavior.

d. When perceptual and motor-skill performance did degrade during prolonged confinement, certain kinds of changes were characteristic:

(1) Omitting portions of simple tasks, or parts of complex perceptual-motor tasks. These omissions may indicate general inattentiveness or boredom.

(2) Approximation. The subject's responses become less accurate and his performance less precise, but they remain minimally adequate to meet the proficiency requirement of the task.

(3) Longer response time. This increase may be due to gross misjudgments of the passage of time or to general lethargy.

(4) Larger and more frequent errors.

(5) Queuing. The subject may delay responding during peak loads, then catch up during lulls.

(6) Lapses. Sometimes subjects' performance shows exaggerated variability.

(7) Stereotyped responses and movements, regardless of the stimulus. The subject may treat all stimuli as if they were equivalent.

(8) Filtering. Subjects may systematically omit certain categories of stimulation and response, according to some subjective priority scheme. Subjects frequently show this filtering when stresses increase markedly.

(9) Operating controls unintentionally.

(10) Failing to detect and respond to stimulus changes. The effects of confinement on task performance are relatively transient. While there may be performance losses for single periods of confinement, repeated confinements give smaller and smaller decrements. The literature consistently indicates that any detrimental effects confinement has on performance can be offset in two ways: by giving the men repeated practice on the tasks they must perform, and by repeatedly exposing them to the confinement situation before they are deployed in an actual field situation.

Predicting Adjustment to Confinement

Eilbert and Glaser (17) attempted to find measures that would predict adjustment to confinement. They selected two extreme groups -- 112 well-adjusted men and 83 poorly adjusted men -- from supervisors' ratings of how well their men had adjusted to an isolated, restrictive Arctic base. Then they compared how these groups responded on 11 measures:

a. Biographical inventory

b. Self-appraisal blank

c. Incomplete-sentences test

d. Medical-symptoms list

e. Modified Taylor Manifest Anxiety Scale

f. Food-aversion list

g. General-information test

h. Peer-nomination form

i. Air Force Aptitude Test

j. Job-proficiency ratings

k. Medical-record data

Weybrew et al. (61), using 109 men as subjects, examined how well adjustment could be predicted from the following measures:

a. Background information from the Standard Psychodiagnostic Record Booklet

b. Shipley-Hartford Retreat Scale (for identifying certain kinds of psychopathology involving organicity)

c. Psychiatric ratings

d. Group Rorschach

e. Combined ratings by psychiatrists and psychologists

f. Sports inventory

g. Neurotic symptom checklist

h. Monthly health diary

i. Line evaluation or rating in overall performance of duty

j. Attitude study questionnaire

k. Group behavior description questionnaire

Epstein (18) used two 110-man fleet ballistic-missile submarine crews to test potential adjustment criteria such as attitudes toward the Navy, attitudes toward fleet ballistic-missile submarine service, rank, performance, military behavior, leadership, appearance, and adaptability.

In summary, the studies attempting to predict adjustment to duty in confined situations have yielded three general conclusions:

a. Well-adjusted men perform best and adapt most easily to confined situations.

b. Relatively few variables are systematically related to confinement adjustment. However, men who adjust to confinement better are older than 21, married, and have more than two years of service.

c. The men who adjusted best to confined conditions at Antarctica had above-average intelligence test scores, low interest in organized sports, high rating of ability to communicate, high rating of ability to cope with aggression, low rating on overt hostility, and less than a college education.

Physical Environment

Human Engineering Laboratories Standard S-2-64 (27) gives design criteria for the confining area of the vehicle fighting compartment. This standard makes specific recommendations for designing the physical environment of a vehicle fighting compartment. The criteria include temperature, ventilation, illumination, humidity, noxious substances, noise, and vibration.

Here are some general conclusions about the physical environment of confined spaces (8, 46, 47, and 48):

a. An ideal work climate is about 68° F with 50 percent humidity. With increased humidity or temperatures above 90° F, manual performance, attention and emotional adjustment would begin to deteriorate. The temperature in a confined space housing several people should not exceed 85° F effective temperature (a measure based on temperature, humidity, and rate of air movement).

b. Manual dexterity begins to deteriorate below 60° F. Below 50° F there is a considerable loss of dexterity, and subjects report pain. Below 40° F subjects begin to lose tactual discrimination, as well as ability to make fine manual movements. Low temperatures also affect hand-eye coordination adversely.

c. Increasing concentrations of carbon dioxide become critical much more rapidly than oxygen deficiency does. Carbon-dioxide concentration should not exceed three percent. Carbon-dioxide concentrations between one and two percent may reduce efficiency slightly, but in general their effects will be negligible. When carbon-dioxide concentrations reach three percent and four percent, there are definite performance decrements. With more than five percent, subjects will breathe with effort and tire quickly. More than 10 percent carbon-dioxide concentration is dangerous; exposing men to such a concentration for any length of time would probably be fatal.

d. Reducing oxygen concentration to 13 percent has serious effects on human performance: handwriting, reaction time, and code translation are disturbed; memory is markedly impaired; word associations are altered; and judgments are not to be trusted. At 10 percent oxygen, there are marked alterations in mood, which may include irritability, lassitude, and anger -- or exhilaration, euphoria, and boisterousness.

e. The safe practical limits for prolonged occupancy of a shelter are 1.5-3 percent carbon dioxide, not less than 17 percent oxygen, and not more than .01 percent carbon monoxide in the air.

f. There are several effective methods to keep odors from concentrating in closed spaces: supplying fresh outdoor air through a simple ventilation system, recirculating indoor air through charcoal filters or through a spray-type dehumidifier, or using deodorants.

Physiological Changes

In general, the physiological changes in heart rate, respiration rate, skin temperature, and electrical skin conductance occurring in confined personnel are due to anxiety-provoking stimuli, rather than the confinement itself. There are usually no marked physiological changes during the first week of confinement. After this, insomnia, headaches, excessive tension and lowered motivation begin to appear, but they are not seriously debilitating (24, 25, 56, and 58).

SUMMARY

The research on how groups behave in confined settings does not allow us to answer our initial questions definitively. The answers we do have involve so many qualifications that they are not directly useful in solving the Army's problems.

Can personnel operate efficiently in a confined situation? Yes. Evidence shows that if people are confined in a comfortable room -- no sensory overload, no sensation of joggling, no smell of exhaust fumes, no temperature extremes, no lack of sanitation, and no strict limits on physical movement -- and if they know that their participation in the study will gain them special treatment and/or prestige -- they can operate efficiently. But can soldiers operate efficiently -- and will they -- when they are confined in a hot or cold (but rarely comfortable) tank or APC, when they are ill from vibration and the smells of diesel fuel and combustion products, when their eyes and throats burn and itch, when sanitary facilities are minimal, when they have room enough to shift position but not to move about, when they know that release from confinement may mean only more stress in face-to-face combat? The answer is not known. These data have not been collected.

Will men perform effectively after they are released from confinement? Here we have relevant data, but the question is still not satisfactorily answered. One series of experiments studied a total of 277 men, most of whom showed significantly degraded combat-relevant skills after they were confined from four to 24 hours in moving and standing, open and closed APCs. But highly motivated subjects (those eager to compete with themselves and fellow crew members for longer confinement durations and high test scores) showed smaller performance losses than other subjects. Other studies bear out this finding: that, not very surprisingly, performance decrements are smaller when subjects are more motivated.

Another important finding: repeated periods of confinement produce adaptation, and subjects show progressively smaller decrements after each successive confinement. However, these experiments involved some natural selection, because men who found the experimental conditions intolerable were allowed to drop out, leaving a more highly motivated, select group. In combat, dropouts cannot leave the vehicle. Not only will they cease contributing to crew performance, but they may even become hindrances. And, in all the studies reported, subjects were aware of being part of a research program with all its special-situation implications, which differ from the field situation.

Does confinement actually degrade performance? The answer can be either yes or no, depending on the type of study and the procedures it used. Giving the Army an answer pertinent to the military situation will require further study.

What are the most appropriate measures of performance effectiveness? Regardless of the myriad procedures used in experiments, the best measures of performance effectiveness are obviously the tasks men will actually have to perform in combat. Measuring intelligence, time estimation, and reaction time gives information about intelligence, time estimation, and reaction time, yet it tells us little about tracking, aiming and firing, navigating, and other tasks men must perform in combat.

We must also remember that subjects in laboratory or simulated field studies are aware of their roles. The results of these studies may be influenced by other variables such as the subjects' sophistication, sets unintentionally induced by instructions, subjects' desire to conform to the experimenters' expectations (or their desire not to), and tendencies for subjects to be dramatic. In an operational field study, these variables would be much less important.

Essentially, we find that:

a. There are many laboratory studies and simulated confinement studies, but their findings cannot be generalized enough to be directly useful in solving the Army's problems.

b. The behavior measures that are most useful in a laboratory or simulated confinement setting are not necessarily best in an operational setting, since the stresses in the former are merely simulated but, in the latter, are real and unavoidable.

c. Few studies yield confinement data pertinent to the Army's need -- to know how men perform during prolonged confinement in an armored vehicle. While we have information about what happens to men in confinement, we have little information relating the man and the system in which he is confined. The Army must consider not just the capabilities of the man alone, but also the interplay between the man and the system in which he is employed.

RECOMMENDATIONS

1. The Army needs information about how men perform combat-relevant tasks under the stresses of prolonged confinement in an armored vehicle in an operational setting.

The most useful data would be obtained by confining crews in buttoned-up armored vehicles and keeping them confined there for specified periods (12, 24, 36, 48 hours).

During the confinement periods the crew would perform the actual combat tasks required in an armored vehicle.

a. Driver

(1) Driving forward or backward cross-country by day and by night over terrain free of obstacles and terrain cluttered with obstacles.

(2) Selecting covered and concealed routes.

(3) Reading and interpreting road and strip maps.

(4) Assisting tank commander in selecting firing position.

(5) Conducting first-echelon maintenance.

b. Loader

(1) Loading and unloading the main gun.

(2) Operating and performing first-echelon maintenance on all vehicle radio communications.

(3) Servicing and performing first-echelon maintenance on main and secondary armament.

c. Gunner

(1) Removing, installing, and maintaining all gunnery material.

(2) Checking and adjusting the fire-control equipment and firing mechanism of the main gun and machine gun.

(3) Acquiring targets.

(4) Firing the main gun and machine gun, using direct-fire procedures.

(5) Firing in special and indirect-fire situations.

d. Commander

(1) Conducting battlefield surveillance.

(2) Selecting routes of travel and firing positions.

(3) Commanding and supervising weapon firing.

(4) Establishing, maintaining, and bearing responsibility for all communications within his vehicle, and between his vehicle and all other vehicles in his platoon.

e. Common tasks

(1) Conducting surveillance.

(2) Maintaining communication.

(3) Performing maintenance during and after confinement.

Crews would be forced to maintain combat activity for the prolonged period, with no way out and no hopes for special treatment immediately after release. No attempts would be made to operate only under good environmental conditions such as clear, cool weather; the design of the vehicle itself would provide the only environmental controls. Immediately upon release, crews would be required to perform a series of combat tasks such as throwing grenades, firing a rifle, and running an obstructed course.

This type of study design would give the Army answers that are most directly pertinent to its questions about confinement in armored vehicles.

2. Since it has been found that trained crew members perform better than untrained men, the study should also consider training procedures such as sequence of subject-matter presentation, transfer of training, special training devices, and rapid training for mobilization.

3. Many of the studies should be conducted directly in the field, using actual vehicles and tactical set-ups to provide practical answers for practical applications. Such field studies would probably be no more expensive than elaborate laboratory tests or simulated field studies, and the data could be applied more directly to the operational situation. Actual field studies can be used only at the cost of control over the variables, but they offer the advantage of more nearly reproducing all the variables, and all the stresses, of combat.

4. The variables associated with confinement in vehicles under field conditions -- monotony, sensory overload, lack of physical activity, and sleep deprivation -- should be investigated and related to performance.

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APPENDIX A

AN ANNOTATED BIBLIOGRAPHY OF CONFINEMENT STUDIES

This appendix is an annotated bibliography of the reports on group behavior in confinement reviewed in this survey. The bibliography is intended to report and not to interpret the information presented in the individual studies.

The reports have been grouped under the following headings:

I. General Problems in Confinement, Isolation, and Sensory Deprivation

Anecdotal Reports

II. Physical Environment of Confined Spaces

III. Effects of Confinement

A. Physiological Changes in Confined Personnel

B. Group Behavior Under Stress

C. Performance Under Confinement Conditions

IV. Predicting Adjustment to Confinement

I. GENERAL PROBLEMS IN CONFINEMENT, ISOLATION, AND SENSORY DEPRIVATION

1. Burke, J. T., Walsh, J. J., Tucker, D. B., Earle, F. H., & Gray, S. E. Men in tanks: Conditions of stress in tank crews and techniques of stress reduction. U. S. Army Armored School, Fort Knox, Ky., May 1952.

This report discusses the stresses that the tank, and the demands of its tactical employment, impose on the men who fight in it. The report is intended to (a) familiarize armor officers with some important human considerations in tank design and tank-crew operation; (b) emphasize the need for integrating the principles of human operation into the design of equipment; and (c) offer techniques for reducing stress on tank crews.

Method

250 men with different tank-crew experience -- half armor officers and half armor officer candidates -- answered a questionnaire about factors which tend to produce stress. The questionnaire dealt with the areas of noise, gun blast, gun recoil, combustion products, vibration, motion, confinement, and maintenance.

Results

Tankers who suffered stress feared three main things: confinement itself, being burned in the tank, and being trapped in the tank. They also expressed fear that an enemy might surprise the crew. There were indications that fatigue may be important. But confinement as such -- physical and psychological restriction -- was unimportant to experienced tankers, and very nearly so for most new men.

Conclusions

1. The confinement tankers experience is not as important a stress factor as other variables, especially for men with training and added experience. Quite probably the comparative safety of a steel shell balances the phobias which they might otherwise develop.

2. Experienced tankers do not consider confinement an important stress-producing factor.

2. Bexton, W. H., Heron, W., & Scott, T. H. Effects of decreased variation in the sensory environment. Canad. J. Psychol., 1954, 8, 70-76. (McGill University study)

This study began with a practical problem: the lapses of attention that may occur when a man must give close and prolonged attention to some aspect of an environment in which nothing is happening, or in which the changes are very regular. Their prime example was watching a radar screen hour after hour.

Method

Male college students were paid to lie on a comfortable bed in a lighted cubicle, 24 hours a day, with time out for eating and going to the toilet. They were paid $20 for each 24-hour period. Throughout each experimental period they wore translucent goggles which transmitted diffuse light but prevented pattern vision. Except when they were eating or at the toilet, the subjects (Ss) wore gloves and cardboard cuffs. The cuffs, extending from below the elbow to beyond the fingertips, permitted free movement of the joints while limiting tactual perception. There was a small intercom system so the S and experimenter could communicate, but talking was minimized. Auditory stimulation was limited because the cubicle was partially soundproof and the S kept his head in a U-shaped foam-rubber pillow while in the cubicle. The continuous background noise provided by fans, air-conditioner, and the amplifier leading to earphones in the pillow was a fairly efficient masking noise.

To measure how this isolation affected cognitive processes, the Ss were tested before, during, and after the isolation period.

During isolation, 12 Ss were given these types of problems to do in their heads: multiplying two- and three-digit numbers, completing number series, making a word from jumbled letters, and making as many words as possible from the letters of a given word. Each S was tested with problems like these before he went into the cubicle, after he had been there for 12, 24, and 48 hours, and three days after he came out of the cubicle. Twelve unisolated control Ss took the same series of tasks at the same intervals.

The Kohs-Block Design Test and the Wechsler Digit-Symbol Test were given before Ss entered the cubicle and immediately after they left it. Subjects were also asked to report any visual imagery they observed.

Results

Subjects tended to spend the earlier part of the experimental session sleeping. Later in the session they slept less, became bored, and appeared eager for stimulation. This boredom seemed to arise partly from reduced capacity to think systematically and productively. Subjects also became very restless, making constant random movements; they described this restlessness as unpleasant. It was

difficult to keep Ss for more than two or three days, although the pay was more than double what they could normally earn. Some Ss left even before their testing could be completed.

During isolation, the experimental Ss performed more poorly than the controls on every test they took. The experimental Ss were also inferior to the controls on the Kohs-Block Design Test and the Wechsler Digit-Symbol Test given immediately after they left the cubicle, and their handwriting showed disturbances.

Isolated Ss reported they had observed visual imagery. Their hallucinations revealed several levels of complexity. In the simplest form, the visual field, with the eyes closed, changed from dark to light, displayed lines, or developed simple geometrical patterns. Fourteen Ss reported such imagery and said it was a new experience to them. More complex forms included "wallpaper patterns," reported by 11 Ss, and isolated figures or objects without background, reported by seven Ss. Finally, there were integrated scenes. Three Ss reported such scenes, which frequently embodied dreamlike distortions, with figures often described as "like cartoons."

In general, the Ss were first surprised by these phenomena, and then amused or interested, waiting for what they would see next. Later, some Ss found them irritating and complained that their vividness interfered with sleep.

There were also reports of hallucinations involving other senses. One S said he heard people in his visual hallucinations speaking, and another repeatedly heard a music box playing. Four Ss described kinesthetic and somasthetic phenomena.

In addition, there were reports of "otherness" and bodily "strangeness." One S said, "My mind seemed to be a ball of cotton-wool floating above my body;" another stated that his head felt detached from his body.

After Ss came out of the cubicle after the experimental session, and removed their goggles, cuffs, and gloves, they seemed dazed. Their visual perception seemed disturbed, but usually only for one or two minutes. They said that the environment tended to appear two-dimensional, and that colors seemed more saturated than usual. Some Ss also reported feelings of confusion, headaches, mild nausea, and fatigue; in some cases, these conditions lasted as long as 24 hours.

Subjects said they were unable to concentrate on anything while in the cubicle.

Conclusions

This study showed that merely limiting the variability of sensory inputs could change performance on an intelligence test and induce hallucinations -- direct evidence that we depend on the environment in a way that had not been recognized previously.

3. Torrance, E. P. What happens to the sociometric structure of small groups in emergencies and extreme conditions. Group Psychotherapy, September 1957.

Emergencies and extreme conditions place unaccustomed stresses upon the sociometric structure of groups. As stress continues, groups appear first to lag before responding, then to make an overcompensating response, and finally, if the stress continues long enough, to collapse.

Under stress, measures of leader and crew attributes are more variable; group members get better acquainted with one another, and become less aware of prestige differences, but they also become less harmonious; official structures tend to give way to informal structures under stress; and in extreme stress, social structure tends to break down without being replaced by any other structure. However, the sociometric structure is generally more stable in effective groups than in ineffective groups.

4. Heron, W. The pathology of boredom. Scientific American, 1957, 196, 52-56.

"Prolonged exposure to a monotonous environment has definitely deleterious effects. The individual's thinking is impaired; he shows childish emotional responses; his visual perception becomes disturbed; he suffers from hallucinations; his brain-wave pattern changes ... studies indicate that normal functioning of the brain depends on a continuing arousal reaction generated in the reticular formation, which in turn depends on constant sensory bombardment. It appears that, aside from their specific functions, sensory stimuli have the general function of maintaining this arousal, and they rapidly lose their power to do so if they are restricted to the monotonously repeated stimulation of an unchanging environment. Under these circumstances the activity of the cortex may be impaired so that the brain behaves abnormally.

"Studies have indicated that hallucinations are fairly common among long-distance truck drivers. After many hours on the road they may begin to see apparitions such as giant red spiders on the windshield and non-existent animals running across the road ...

"A changing sensory environment seems essential for human beings. Without it the brain ceases to function in an adequate way, and abnormalities of behavior develop. Variety is not the spice of life; it is the very stuff of it."

5. Biderman, A. D. The relevance of internment for the problem of shelter habitability -- working paper. Disaster Research Group, Division of Anthropology and Psychology, National Academy of Sciences, National Research Council, Washington, D. C., 1959.

This paper discusses the implications that internment literature has for fallout-shelter habitability, under the following headings: (a) physical deprivation; (b) psychological deprivation; (c) immobility and confinement; (d) impotence (in regard to status and role); (e) limited information regarding external environment; (f) severed social relationships; (g) unfamiliarity; (h) threat, anxiety, and uncertainty; (i) nature of the distributive system; and (j) involuntary association.

Conclusions

1. "... inactivity, boredom, and monotony increase distress and discomfort from many sources. This generalization has greater relevance to persons who are well-fed and possess a surplus of energy beyond that required to sustain existence than it does to the starved, exhausted, or debilitated person."

2. "One possible lesson from the military experience is that training and information can create a general disposition to act in a crisis -- to attempt to cope with the crisis."

6. Freedman, S. J. & Greenblatt, M. Studies in human isolation. Technical Report 59-266, Aerospace Medical Laboratory, Wright Air Development Center, Ohio, September 1959.

Since it is difficult to compare various sensory-deprivation studies that use different procedures, techniques, subjects, and theoretical orientations, the authors designed this research to answer two specific questions:

a. How are perceptual distortions and hallucinations (and other cognitive effects) related to each other in a sensory-deprivation experiment?

b. How does varying the nature of the visual input affect perceptual distortions and hallucinations?

Method

Thirty college students (27 male, 3 female), selected as stable personalities from psychiatric interviews and autobiographical information, were paid to serve as Ss. Their ages ranged from 17-28. They had no formal background in psychology. These students were divided into three groups of ten Ss, and each group was tested under a different condition.

Each S had psychiatric interviews and psychological tests both before and after an eight-hour experimental session. Galvanic skin response (GSR) and electrocardiograms (EKG) were recorded intermittently during a session, and behavior was observed regularly.

Before the first interview, each S received a form briefly describing the conditions of the experiment. At the beginning of the experimental session, he was instructed to report whatever thoughts, feelings, sensations, dreams, images, etc., occurred to him. His comments were tape-recorded. The S lay on a comfortable bed in a small room. Subjects wore earphones which presented a constant "white noise" (a random mixture of many frequencies). The noise level was adjusted to obscure ambient noises without becoming too disturbing or painful. Although the white noise masked most ambient sounds, Ss were able to hear occasional airplanes overhead and slammed doors. In general, normal auditory stimulation was blocked off and replaced with continuous non-patterned stimulation. The Ss also wore heavy cotton gloves to reduce tactile stimulation, and cardboard cuffs on their forearms that extended beyond the fingertips. Subjects were told to remain on the bed throughout the experiment and not to move about excessively. During the session, nobody entered the room or spoke to the S.

a. The "non-patterned" or diffuse-light group (10 Ss) wore translucent goggles. Except for the dark contour of the goggle frames, the visual field was moderately intense, diffuse, and homogeneous.

b. The "visual deprivation" or blackout group (10 Ss) was treated in exactly the same way except that, instead of translucent goggles, they wore blackout goggles, and the room was darkened.

c. The "social isolation" or control group (10 Ss) was treated exactly like the first two groups, but wore neither goggles, earphones, gloves, or cuffs. The Ss were relatively isolated socially, but their sight, hearing, and touch were relatively unrestricted.

Procedure Sequence

All pre-test procedures were repeated after the experimental session to evaluate changes.

a. Psychiatric interview -- a few days before session.

b. Psychological tests -- immediately before session.

(1) Bender-Gestalt test.

(2) Visual perception tests (discrimination of simple forms, size constancies, optical illusions).

(3) Depth perception -- Howard-Dolman apparatus.

(4) Visual-motor coordination -- pursuit-rotor.

(5) Perceptual lag -- specially designed apparatus.

c. Eight-hour experimental session.

(1) Resistance GSR taken continuously with plantar electrodes for 15 minutes out of every half hour.

(2) EKG recorded intermittently.

(3) Behavior observed regularly during session; all vocalizations tape recorded.

d. Repeat psychological tests -- begun immediately after session and continued until S performed at his pre-test level.

e. Clinical-type interview -- immediately after testing.

The interviews before and after the session were conducted along the lines of the associative history-taking. All interviews were recorded for later analysis. Before the experiment, the interview focussed on motivation, expectations, anxiety, object-relations, self-concept, defenses, and visual imagery. Following the session, the interviewer tried to find out as much as possible about the actual thoughts, sensations, feelings, and fantasies which had occurred during the session.

Results

1. Perceptual: "The fact that changes occur with both diffuse light and blackout indicates that it is the absence of order and/or meaning which tends to degrade perceptual organization, rather than the specific nature of the stimulus field; ... we must, therefore, think in terms of an active process in the waking state which strives or seeks continuously and automatically to find ordered relationships in the perceptual environment ... we would postulate that it is this process of seeking order where there is no order and attempting to incorporate non-order into previously existing schemata, which accounts for the perceptual changes, instabilities and inconstancies ... Our data suggest that these effects may be due to the release of tendencies inherent in the primitive perceptual process but normally held in check by a process of structuring and stabilizing the visual field."

2. Hallucinations: "... the production of imagery in sensory deprivation seems to be related to a homogeneous visual field regardless of its intensity. Restricted mobility is probably important but not demonstrated in the present research. The imagery closely resembles hypnogogic and hypnopompic imagery in its formal characteristics, mode of appearance, and content. Subjects with a history of hynogogic imagery will be more likely to report imagery in sensory deprivation.

"The general characteristics of the visual imagery in the experiment are:

a. Subject matter and form seemingly irrelevant to to the subject's past experience and current situation;

b. Images cannot be controlled as to content, appearance, or duration;

c. Vivid colors and striking detail appear;

d. Duration is very short, with apparently unrelated succession of images."

3. Other results: "In addition to the perceptual changes and hallucinatory-like imagery already noted, most experimental subjects reported changes in cognitive functioning and changes in feelings about themselves, about others, and about the environment; none of the controls gave such reports."

Conclusions

1. Sensory deprivation can produce perceptual and cognitive effects, similar to those found in the Bexton, Heron, and Scott (McGill) study, in normal Ss in eight hours or less.

2. The most striking perceptual effects this study obtained were the Ss' reports and drawings of how simple forms looked to them. However, more precise techniques, such as the Perceptual Lag test, can quantitatively measure effects which would probably otherwise pass unnoticed.

3. Both kinds of effects appear with either of the two kinds of homogeneous visual fields: (a) bright diffuse light, and (b) blackout. Thus the most important determinant seems to be homogeneity of field, rather than intensity of stimulation, in the absence of normal patterned vision.

4. There is significantly more perceptual distortion with diffuse light than with the blacked-out visual field.

5. Cognitive effects do not differ significantly under the two different conditions, either in kind or amount.

6. Control Ss (social isolation alone) report essentially none of the effects in either category.

7. For a given person, perceptual changes and cognitive changes do not seem to be correlated significantly. An individual may show gross perceptual changes without concomitant cognitive changes, and vice versa.

8. The visual imagery reported strongly resembles hypnogogic imagery (produced by drowsiness) in form, content, and mode of appearance.

9. Individuals who normally experience hypnogogic imagery and have rich visual experiences are generally more apt to report hallucinatory imagery in the sensory-deprivation experiment.

7. Wheaton, J. L. Fact and fancy in sensory deprivation studies. Aeromedical Reviews, Review 5-59, School of Aviation Medicine, Air University, Brooks AFB, Texas, May 1959.

The first chapters present a brief review of the research leading up to current studies on sensory deprivation. The broader issues are outlined in the third chapter. Chapters IV and V summarize published reports (autobiographic, anecdotal, clinical literature, and experimental literature). The final chapters summarize present knowledge of how isolation affects human behavior and discuss the probable military implications.

With increasing interest in the research on sensory deprivation at McGill University (Bexton, Heron, and Scott), it became evident that understanding sensory deprivation systematically would involve several other, related psychological concepts. These include fatigue, monotony, boredom, and isolation, which are interrelated concepts involving closely associated behavioral processes. It became apparent that the phenomena under review affected human behavior in a much broader range of military situations than merely interrogating prisoners of war. Isolation, monotony, and sensory deprivation also characterize the environment of some equipment operators, as well as of small groups working at remote outposts.

Background of the Sensory Deprivation Research

"To place the research on sensory deprivation in perspective," Wheaton says, "it must be treated as a problem involving the effects of certain organism-environment interaction situations on efficiency of human performance. One may begin with a general question concerning the factors which could cause a healthy, normally functioning, well-motivated individual to react inefficiently. In order to study this, factors associated with performance efficiency are examined. One factor is that of the deleterious effect of boredom in monotonous situations. Another factor is the apparent paradox that although accuracy and rate of performance decrease with time during concentration on a task, they may be restored by disturbing the subject." Wheaton goes on to cite representative experiments and to distinguish two types of fatigue: fatigue from heavy work, and fatigue from mental and sedentary work. He surveys in detail some attempts to use drugs to improve or restore effectiveness.

"Sensory deprivation," Wheaton continues, "consists of a reduction of the totality of stimulation in the environment, thus reducing the nonspecific arousal stimulation." On theoretical grounds, he says, such sensory reduction could be shown to involve the variability and intensity of sensory stimulation. Sensory deprivation engenders isolation to the extent that the individual is shut off from sources of information, regardless of how this is accomplished; as a result of monotonous stimulation he is separated from, or isolated from, the environment. Sensory deprivation may vary quantitatively, along a continuum, from one extreme to the other.

The Nature of Isolation

Essentially, isolation separates an individual from the objects normally in his environment. But this separation can occur in a number of ways, and it may vary in degree. The objects the individual is isolated from may vary in significance to him. Also, the conditions of isolation may involve various kinds of barriers, active or passive, internal or external, and threatening or non-threatening, all with varying degrees of permanence and permeability.

There are three ways to isolate an individual: (a) confining him to a limited space, (b) separating him from particular stimuli to which he has attachment or dependency needs, and (c) separating him from the environment by reducing the areas of stimulation.

Analyzing any particular case of isolation would require (a) characterizing the mode of isolation; (b) identifying the nature, strength, and permanence of the barriers; and (c) describing the isolated individual's motivation and personality. With isolated groups, there is also a fourth consideration: distinguishing the organization, structure, and functional relationships within the group.

Review of Anecdotal and Clinical Literature on Isolation

Wheaton includes accounts of cases of solitary sailors, isolation resulting from shipwrecks, frontier and arctic isolation cases, and isolation in clinical medicine.

Review of Experimental Literature

Despite great interest in sensory deprivation, surprisingly little research about it has been published. The pioneer work was done at McGill University. Subsequently, closely related work was published independently by Vernon (at Princeton) and by Lilly. To facilitate comparison of the work, a topically organized summary is included in this paper. The three groups of investigations are compared as to type of stimulus situation, subjects, procedures, and other significant dimensions.

Summary of Present Knowledge of Isolation Effects on Human Behavior

The material presented in this review illustrates a wide range of personal experiences of isolation and survival incidents, supplemented by a smaller number of systematic investigations.

Studies show that isolation is a complex phenomenon producing a characteristic progression of symptoms. These symptoms, mainly subjective, are predictable variations from individual behavior-pattern norms. How greatly and how quickly the symptoms develop appears to depend directly on the intensity, complexity, and duration of the stress of isolation. Several factors may modify the stress:

a. Types of isolation imposed.

b. Complications of additional stresses: hunger, thirst, physical discomfort, injury, or illness.

c. "Stressfulness" of the particular stress combination to the particular individual.

d. The individual's ability to function well within a group.

e. Previous experience in isolation.

This presupposes a recognizable and predictable basic syndrome that can be altered by the modifying conditions listed. Accumulating evidence in anecdotal and experimental accounts does support the hypothesis that there is a definite symptom-complex or isolation syndrome.

Implications for Military Problems

Continued investigations of sensory deprivation promise to shed light on various specific military problem areas. Some special applications are already apparent:

a. Assigning personnel to small isolated bases for prolonged periods of time.

b. Formulating a defense to help the individual withstand the technique of prisoner interrogation that has become known as "brainwashing."

c. Designing sealed-cabin experiments so they will generate and supply further information.

8. Ormiston, D. W. A methodological study of confinement. Technical Report 61-258, Wright Air Development Division, Wright-Patterson Air Force Base, Ohio, March 1961.

This study ... ed to develop better measures of how personality affects reactions to confinement, and of psychomotor performance during confinement.

Method

Four visual illusions were chosen as possible criteria: the phi phenomenon, the autokinetic phenomenon, the spiral aftereffect, and Necker's reversible cube.

A battery of personality tests gave personality measures that could be correlated with reactions to confinement: Edwards Personal Preference Schedule, Minnesota Multiphasic Personality Inventory, Allport-Vernon-Lindzey Study of Values, Time Orientation Survey, and Perceptual Generalization Test.

Two tasks measured psychomotor performance. A monitoring task, in which Ss responded to a red warning indicator, was programmed to present stimuli randomly at intervals from one to 30 minutes. A dual compensatory tracking task was administered in an initial practice period, at the end of the first hour, and every two hours thereafter. Throughout the confinement, subjects made continuous estimations of successive ten-minute time intervals. The S also recorded somatic complaints arising during the study.

Thirty-four male, volunteer undergraduates were seated in aircraft chairs in a lighted 5' by 8' room, and confined individually for eight hours. Another group of 26 men, used as controls, were not confined, but performed the same tasks. The illusions were administered before and after the confinement.

Results

1. The spiral aftereffect appears to have some promise as a criterion measure. At the end of the experiment, the aftereffect persisted longer for Ss who ha[illegible]n confined, but had a shorter duration for the Ss who had not been confined.

2. The onset of the autokinetic effect did not change significantly.

3. Fluctuations of a reversible figure and the phi phenomenon threshold gave conflicting data, indicating that they are not good criterion measures.

4. There was no obvious relationship between performance during confinement stress and somatic complaints or personality measures.

5. Intermittent performance on a relatively simple tracking task, using a time-on-target measure, does not seem likely to provide a sensitive index of the effects of short-term confinement stress.

6. Although it has already been established that boredom's effects can be measured with tasks that require constant monitoring, such tasks may measure less effectively when Ss perform other tasks as well. Interpolating additional tasks apparently relieves boredom and restores performance on the monitoring task.

7. Time estimation may be useful under certain conditions, but it did not prove to be a useful criterion measure in this study.

8. It would be desirable to conduct experiments at the operational level, where the Ss are not aware of their roles as Ss. Operational experiments would eliminate unwanted factors like Ss' sophistication, suggestion to the S through instructions, S's desire to conform to the experimenter's expectations, and any tendencies for the S to be dramatic in the laboratory situation.

9. Imus, H. A. Psychological factors in space travel. Special Report 61-4, Naval School of Aviation Medicine, Pensacola, Fla., June 1961.

This report reviews literature about psychological factors in space travel, as a first step toward predicting man's ability to perform in a manned-vehicle space flight.

Several propositions are offered:

a. Motivation and morale may be controlled by extensive physiological, psychological, and psychiatric screening procedures.

b. Boredom and fatigue may be controlled, in part, by scheduling activity appropriate to the mission.

c. The effects of isolation may be reduced by adequate communication with monitoring stations.

d. Anxiety may be minimized by perfecting equipment so highly that the men have complete confidence their mission will be successful.

In general, the best guarantee of a successful mission seems to be selecting men who have performed a variety of hazardous missions consistently and reliably over a period of years.

10. Zubek, J. P., Aftanas, M., Kovach, K., Wilgosh, L., & Winocur, G. Effect of severe immobilization of the body on intellectual and perceptual processes. Canad. J. Psychol., 1963, 17, 118-133.

The purpose of the experiment was to determine whether restricting kinesthetic stimulation severely would, by itself, produce any of the typical sensory and perceptual deprivation phenomena.

Method

Forty Ss were strapped individually into a specially constructed box which kept them from moving their limbs, trunk, and head for as long as 24 hours. Visual and auditory stimulation were not restricted. A battery of seven intellectual tests and eight perceptual-motor tests was administered before and immediately after the immobilization period. A questionnaire on experience in isolation was also given after immobilization. Two groups of 40 recumbent and 40 ambulatory control Ss took the same tests at the same times.

Results

1. As compared to the recumbent control Ss, immobilized Ss were significantly more apt to report intellectual inefficiency, bizarre thoughts, exaggerated emotional reactions, time distortions, changes in body image, unusual body sensations, and various physical discomforts.

2. Hallucinatory phenomena did occur, but only rarely.

3. The perceptual-motor tests showed significant impairment of dexterity, kinesthetic acuity, color discrimination and handling of reversible figures.

4. Perception of simple patterns was also affected somewhat.

5. There was no change in pain sensitivity, tactual acuity, or results of a cancellation-of-figures test.

6. None of the tests of the intellectual battery revealed impairment.

The study concluded that reducing kinesthetic stimulation alone can produce behavioral changes that are, in many respects, similar to those which occur under reduced visual and auditory stimulation.

ANECDOTAL REPORTS

1. DePoncins, G. Kabloona. New York: Reynal and Hitchcock, 1941.

A French anthropologist who spent four months with a Hudson Bay Post trader in the Central Arctic has described how irrational antagonisms develop among confined people.

"I liked Gibson as soon as I saw him, and from the moment of my arrival we got on exceedingly well. He was a man of poise and order; he took life calmly and philosophically; he had an endless budget of good stories. In the beginning we could sit for hours ... discussing with warmth and friendliness every topic that suggested itself, and I soon felt a real affection for him. But as winter closed in around us, and week after week our world narrowed until it was reduced ... to the dimensions of a trap, I went from impatience to restlessness, and from restlessness finally to monomania. I began to rage inwardly and the very traits in my friend ... which had struck me in the beginning as admirable, ultimately seemed to me detestable. The time came when I could no longer bear the sight of this man who was unfailingly kind to me. That calm which I had once admired I now called laziness; that philosophic imperturbability became in my eyes insensitiveness. The meticulous organization of his existence was maniacal old-maidliness ... I could have murdered him."

2. Gibson, W. The boat. Boston: Houghton Miffiin (The Riverside Press), 1953.

Walter Gibson gives an anecdotal account of 80 survivors from a torpedoed transport, who were confined on a 28-by-8-foot lifeboat designed for 28 people. When the boat finally reached land, after 28 days afloat in the Indian Ocean, only four of the 80 had survived.

The people had suffered horribly from sun, lack of food, thirst, and exposure. All began to hallucinate during the first week, and their hallucinations were always wish-fulfilling: rescue, food, drink. One individual's delusion would spread to others: several people drank sea water, deluded that it was fresh.

Eventually, because of desperate thirst, everyone drank sea water; in tiny quantities, it produced no ill effects. On the third day people started drinking their urine, but it soon became so concentrated and acid that it was undrinkable.

One by one, people died from exhaustion, fighting, sun, hunger, exposure, and the effects of their delusions. Some were murdered and cannibalized by a five-man gang, but these men were finally overcome and thrown into the sea. No man attempted to rescue anyone who was unable to get back to the boat after a swim. No one who left the boat after deluding that he could swim for help was restrained or helped back. Each person who committed suicide would first attempt to destroy the others by throwing rations overboard or by pulling the boat bung to let water in.

Walter Gibson was the only white man who survived. He credits his survival partially to viewing everything that happened passively and quiescently, while remaining determined not to die.

II. PHYSICAL ENVIRONMENT OF CONFINED SPACES

1. Murray, E. J. The psychological effects of adverse environmental conditions and their implications for adjustment in fallout shelters -- working paper. Disaster Research Group, Division of Anthropology and Psychology, National Academy of Sciences, National Research Council, Washington, D. C., 1959.

The study is divided into these categories: (a) psychological effects of nutrition deprivation, (b) psychological effect of atmospheric conditions, (c) psychological effect of fatigue conditions, (d) psychological effects of sensory conditions, (e) psychological effects of confinement conditions, and (f) interaction of two or more conditions. This review will discuss the last five of these categories.

Psychological Effect of Atmospheric Conditions

Heat and Humidity

An ideal work situation is about 68° F with 50 percent humidity. Temperatures above 90° F or more than 50 percent humidity would probably degrade manual performance, attention, and emotional adjustment. Temperature in a confined space housing several people should not exceed 85° F effective temperature.

Cold

Manual dexterity begins to deteriorate below 60° F. Temperatures below 50° F degrade dexterity greatly, and Ss report pain. Below 40° F, Ss begin completely losing tactual discrimination and manual skills requiring fine movements. Low temperatures also affect hand-eye coordination.

Oxygen Deprivation and Related Factors

One of anoxia's clearest effects is on the blurring of vision. At about 13 percent oxygen, handwriting, reaction time, code translation, and recent memory are also disturbed. At about 11 percent oxygen, the person's handwriting becomes more illegible and he misspells words. His memory is markedly impaired, his word associations are altered, and his judgments become unreliable. A man typically lacks insight into his own condition; he does not realize his performance is deteriorating. At 10 percent oxygen or less, there are marked alterations in mood -- sometimes in the direction of irritability, lassitude, and anger, or sometimes toward the other extreme of exhilaration, euphoria, and boisterousness. There are sometimes delusions and hallucinations.

Carbon monoxide, which interferes with oxygen transport in the blood, tends to magnify the effect of low oxygen concentration.

For an enclosed air space that people occupy, carbon-dioxide concentration should not be greater than 0.5 percent. Concentrations between one percent and two percent do not produce any gross changes in performance, although they may cut down a person's efficiency. When carbon-dioxide concentration rises above three percent, breathing will be slightly effortful; above five percent, people breathe heavily and tire quickly. If more than ten percent is present for any length of time, it will be fatal.

Odors and Related Factors

The odors most commonly experienced in a fallout shelter will be those from the human body. These odors depend primarily on sweat, and tend to increase in warm atmospheres. They may also come from the mouth.

With an air space of 500 cubic feet per person, a clean air supply of seven cubic feet per minute (cfm) per person will keep odor intensity within allowable limits for a roomful of sedentary adults. If group shelters provide only 65 cfm of air space per person and three cfm of fresh air, there will almost certainly be disagreeable odors. In overcrowded areas, intense odors may contribute to nausea, vomiting, and low morale.

Psychological Effect of Fatigue Conditions

Fatigue and Inactivity

Besides needing rest, organisms also need activity. If we sleep in one position all night, for example, we wake up cramped and fatigued. After white rats live one or two days in cages so small they can hardly turn around, they show about 25 percent more activity when released to a larger area. Generally, inactive people adjust to restricted movement fairly easily, but highly active individuals do not.

Psychological Effect of Sensory Conditions

Noise

Most people consider sounds unpleasant if they are 80 dB or louder, and painful when they get as loud as 115 to 130 dB. High-pitched tones are more disturbing than low ones. The most pronounced effect of noise is subjective feelings of annoyance. It has little effect on human performance, except for degrading vigilance, but it does produce irritation, fatigue, and aggressive impulses.

Illumination

Low illumination imposes a stress that is reflected in increased muscular tension. Tension is high with one foot-candle of light, but decreases rapidly as illumination is increased to 10 foot-candles.

Poor illumination may degrade otherwise adequate performance and heighten the tension which accompanies work. Adequate lighting and color may help morale. Total darkness frightens many people, and some people ascribe this feeling partly to remnants of primitive childhood anxieties.

Sensory Deprivation

When subjects were kept in a dark, soundproof chamber for five days, they regressed somewhat. They were preoccupied with phallic sexuality and excretory functions, and they emphasized eating and oral gratification. They also became more overtly hostile toward one another.

Psychological Effect of Confinement Conditions

Space and Crowding

As six men were confined in a small chamber for seven days, their performance on psychomotor tasks got progressively less efficient and less accurate. However, there was no deterioration on tests of judgment, learning, reasoning, or intelligence. Morale was initially very high, but it dropped drastically after four days, finally rising again near the end of the experimental time.

There is some evidence that people who have difficulty with authority -- including both people who rebel against authority and those who cling to it -- have more difficulty adjusting to confinement.

Interaction of Two or More Conditions

Hunger, temperature, and activity have important interactions. When the external environment is cold, the body must produce more heat; when the external temperature is high, the body keeps the temperature down by reducing oxidation. Increasing activity causes more oxidation.

The effects of heat are exaggerated if the air in the room is stale and full of unpleasant odors. Certain odors may reduce appetite and cause anxiety.

Fatigue is both an adverse condition in itself and an effect of nearly all other adverse conditions.

2. Anderson, W. L. Atmosphere control in confined spaces. Naval Res. Rev., June 1960, 7-11.

Anderson discusses methods for maintaining an equilibrium between the respiratory metabolism of man and the oxygen, carbon dioxide, and toxic-trace content of the air in a closed space. He describes the standard cyclic systems of atmosphere control used in submarines and those proposed for prolonged submersions. He considers the principles of atmospheric control in submarines the same as for manned cabins in proposed space vehicles, and suggests applying developments in one medium to the other.

3. Muraoka, J. S. Shelter habitability studies. Odors and requirements for ventilation. Technical Report 146, U. S. Naval Civil Engineering Laboratory, Port Hueneme, Calif., May 1961.

This report describes studies of how body and tobacco-smoke odors affect man. It gives the following ventilation requirements for removing these odors from enclosed structures:

a. In hot weather (temperature ranges not defined by author), 20 cfm of fresh air (refrigeration may be required) and 100 cubic feet of space per person.

b. In temperate weather, ten cfm of fresh air and 70 cubic feet of space per person.

c. In cold weather, seven cfm of fresh air and 50 cubic feet of space per person.

Two important factors affecting the quality of the air are the number of persons occupying a shelter and the fresh air supply. The outdoor air temperature, humidity, and number of occupants influence the amount of fresh air needed to maintain a comfortable atmosphere in the shelter.

Some effective methods for reducing the concentration of body and tobacco-smoke odors in closed rooms are bringing in fresh outdoor air through a simple ventilation system, recirculating indoor air through charcoal filters or through a spray-type dehumidifier, using deodorants, and increasing the room's temperature and humidity.

4. Muraoka, J. S. Shelter habitability studies. The effect of oxygen depletion and fire gases on occupants of shelters. Technical Report 144, U. S. Naval Civil Engineering Laboratory, Port Hueneme, Calif., July 1961.

Muraoka studied the literature describing how various gases affect shelter habitability. When personnel in closed areas breathe air that has too much carbon dioxide and carbon monoxide, or too little oxygen, they experience various physiological effects ranging from simple headache to unconsciousness and death.

Shelters should have chemical oxygen generators, as well as carbon-dioxide absorbents to improve breathing conditions in closed shelters.

Results

1. When personnel occupy enclosed spaces, the accumulation of carbon dioxide becomes critical much more rapidly than depletion of oxygen does.

2. Maintaining normal atmospheric concentration of carbon dioxide in shelters means removing about 0.74 cubic foot of carbon dioxide per man-hour of shelter occupancy.

3. The safe practical limits for prolonged shelter occupancy are concentrations of not more than 1.5 percent carbon dioxide, not less than 17 percent oxygen, and not more than 0.01 percent carbon monoxide in the air.

III. EFFECTS OF CONFINEMENT

A. Physiological Changes in Confined Personnel

1. Weybrew, B. B. Psychological and psychophysiological effects of long periods of submergence. I. Analysis of data collected during a 265-hour, completely submerged, habitability cruise made by the USS Nautilus (SSN571). Report 281, Vol. 16, No. 3, U. S. Naval Medical Research Laboratory, New London, Conn., February 1957.

Problem

This study assessed some of the psychological and psychophysiological changes observed in a representative sample of men during an 11-day, completely submerged cruise.

Method

Thirty enlisted men had daily tests of visual sensitivity (critical flicker-frequency thresholds), muscular tension, heart and respiratory rates, as well as self-ratings on 28 fatigue-like variables.

Results

The men showed good adaptation to the conditions of submersion until the sixth to eighth days. Thereafter they began to suffer from insomnia, headaches, and excessive tension, and their motivation dropped -- but not so much that they were seriously disabled. On the last two days, the men seemed to begin adapting more effectively; but these results were considered spurious because of the "end spurt" previously observed in men who live in confined environments for prolonged periods.

2. Tiller, P. R. & Figur, A. M. Environmental requirements of scaled cabins for space and orbital flights: A second study. Part IV. Concentrations of epinephrine and norepinephrine in urine during confinement in a simulated space chamber. Report 416, Air Crew Equipment Lab., U. S. Naval Air Materiel Center, Philadelphia, Pa., November 1959.

Problem and Method

Tiller and Figur studied how eight days' confinement in a simulated space-chamber affected the concentration of epinephrine and norepinephrine in urine. They determined these concentrations for six men, before, during, and after confinement.

Results

1. They found no significant increase in norepinephrine, except on the fifth day, when an emergency situation was introduced.

2. Epinephrine values during confinement were approximately 15 μg per 24 hours -- about twice the amount found in post-confinement determinations.

Conclusion

Confinement, as a stress-provoking situation, significantly increases the excretion of epinephrine.

3. Hanna, T. D. Environmental requirements of sealed cabins for space and orbital flights: A second study. Part V. Some physiological measures on confined subjects breathing recycled gases for eight days. Report NAMC-ACEL 417, Air Crew Equipment Lab., U. S. Naval Air Materiel Center, Philadelphia, Pa., September 1960.

Problem and Method

This study confined six men for eight days at sea level in a small chamber with approximately 75 cubic feet per man. During confinement the same air was continually processed through a closed-cycle oxygen generating system and rebreathed. Bioelectric variables -- heart rate, respiration rate, forehead skin temperature, and plantar electrical skin conductance -- were measured during seven of the eight days of confinement.

Results

Under the experiment's limited conditions, eight days of confinement apparently did not produce any marked changes in these physiological functions. Some changes that did occur seemed to arise from superimposed factors which produced anxiety.

4. Hanna, T. D. A physiologic study of human subjects confined in a simulated space vehicle. Aerospace Med., 1962, 33, 175-182.

Problem and Method

Hanna examined how eight days of confinement affected six men who monitored a vigilance work station in a simulated space capsule. He used four bioelectric measures as criteria: heart rate, respiration rate, forehead skin temperature, and electrical skin conductance. Also, urinalyses determined epinephrine and norepinephrine secretion before, during, and after confinement.

Each crew member maintained watch at the vigilance work station for two hours, went off duty four hours, and then returned for two more hours duty during each 24-hour period. Each man had approximately 75 cubic feet of space.

Results

1. In general, all indices were high initially, as would be expected in a new and unfamiliar situation.

2. By the second, third, or fourth day, all values had decreased from the first day, as the crew adjusted to the new milieu.

3. Introducing an emergency on the fifth day caused sharp increases in the values of every variable.

4. All values fell on the sixth day, but electrical skin conductance remained steady. This indicated some degree of adjustment to the fifth-day emergency.

5. On the seventh day, high electrical skin conductance and decreased heart rate and norepinephrine excretion indicated that the crew was alert and looking forward to the termination of the experiment, but physically relaxed. Physiologic measures were not obtained for the eighth day.

Conclusion

The significant differences in physiologic functions were due to anxiety-provoking stimuli, rather than to the confinement itself.

B. Group Behavior under Stress

1. Kinsey, J. L. Report of psychiatric studies on Operation Hideout. Report 230, U. S. Naval Medical Research Laboratory, New London, Conn., July 1953.

Operation Hideout studied the effects of prolonged exposure to increased concentrations of carbon dioxide. While the primary mission was obtaining physiological data, confining 23 men together for two months also provided a unique and interesting situation for psychiatric, psychological, and sociological studies.

Method

This study confined 23 men aboard a submarine for two months. Four measures were obtained: (a) a pre-experiment psychiatric interview summarized into a brief personality sketch, (b) daily written comments elicited from each volunteer, but without attempting to structure or channel the material, (c) casual observation and conversation with various volunteers on daily visits to the submarine, and (d) a structured questionnaire of four questions at the end of the confinement period.

Results

1. There were no major psychiatric problems.

2. There were periodic moderate increases in anxiety, reflected in increased productivity, complaints both physical and non-physical, and changes in mood and behavior.

3. Individuals who revealed unstable personality factors during the pre-experiment psychiatric assessment had more severe and more prolonged subjective physical complaints. Individual performance could be predicted roughly from the psychiatric assessment.

2. Lanzetta, J. T., Haefner, D., Langham, P., & Axelrod, H. Some effects of situational threat on group behavior. J. abnorm. soc. Psychol., 1954, 49, 445-453.

This study attempted to determine how situational threat affects the behavior of interacting individuals: how does varying the threat to a group change the group-members' behavior?

"Variation in threat," Lanzetta says, "can occur along several dimensions: nature and/or intensity, locus in time, locus in 'psychological' space, and target. The latter two are peculiar to a concern with group processes and have no counterpart if the locus were the individual acting alone. 'Locus in psychological space' refers to the origin of threat: whether it arises from some internal group process or originates from an external to the group source. Either the threat is directed to the group as a whole or to individual group members. These two dichotomized dimensions were the independent variables for this study."

Method

Thirty-six threat and nine control (non-threat) groups, of three students each, worked in a laboratory setting on a task called "intercept." Threat was imposed by structuring the sessions as evaluation tests, the results of which would become part of the subjects' ROTC records. The 36 threat groups were divided randomly into four classes of nine groups each, with each class assigned to a different cell of a 2 x 2 factorial design. The main variables were locus of threat (external vs. internal to the group) and target of threat (directed to the group as a whole vs. to the individual group member).

A variety of measures was obtained: records of the on-going behavior of group members, trait ratings of each member, ratings of group characteristics, and subjects' perception of their group and of their own motivation state. The results were analyzed primarily by analysis of variance.

Results

1. Locus and target did not prove to be significant variables, very likely because the measures were insensitive. All threat groups were therefore combined and compared with the control groups. Threat affected behavior in three main areas:

a. Threat-group members showed less behavior that would produce tension and friction within the group and more behavior oriented toward group acceptance.

b. Threat-group members were less task oriented, and they were less forceful, assertive, and active in attacking the task problem. They were also more variable in these areas.

c. Threat-group members were less efficient and adaptable, and their effectiveness was more variable.

2. The results of comparing threat and control conditions may be summarized as follows:

a. Threat appears to reduce forceful, assertive, aggressive, interpersonal, and task-directed behavior, and to increase concern about group acceptance. These changes may mean group members attach more importance to keeping tensions within the group at a low level, than to effective task activity.

b. Threat degrades group effectiveness and makes effectiveness more variable. This result is similar to those obtained in studies of individual performance under stress, where a majority of experiments have shown that stress impairs verbal and perceptual-motor performance.

3. Lanzetta, J. T. Group behavior under stress. Human Relations, 1955, 8, 29-51.

This study investigated the ways that situational stress affects the behavior of individuals interacting in small groups.

Method

This study's primary concern was how stress might affect the interaction of group members attempting to work cooperatively on a group task.

The three descriptive levels used in this study were: (a) group properties (cohesiveness), (b) interaction patterns (agreeing and disagreeing behaviors), and (c) individual characteristics (leadership, striving for group recognition).

Twelve groups, each composed of four Naval Reserve officer trainees, were exposed to three experimental conditions varying in the amount of "stress" imposed. The 12 groups were divided randomly into two classes (six groups each): "high motivation," where the group that performed best was rewarded with a group prize; and "low motivation," where there was no reward. Within both classes, each group got the three stress conditions in a different one of the six possible orders. Reactions were evaluated with examiner observations, subject reports, and ratings of group characteristics and members.

Results

1. Lanzetta found that increasing the stress gave less disagreements, arguments, aggressions, deflations, and other negative social-emotional behaviors, and more collaborations, mediations, and cooperations. As stress increases, individuals apparently try to keep interpersonal tensions at a low level, substituting positive, group-oriented behaviors for negative, individually oriented behaviors.

2. These behavior changes should change the way observers and subjects perceive the characteristics of the group. Ratings of group characteristics showed that, under greater stress, both observers and participants saw the groups as less competitive, more cooperative, and more friendly. These changes almost certainly reflect the tension within the group and increasing internal harmony.

3. Data from still another source -- ratings of individual characteristics -- support this finding. Under high stress, individuals were rated more cooperative, less aggressive, less oriented toward individual solution of problems, and less confident than without stress. The first three changes can be interpreted as decreasing the friction and increasing the harmony within the group, while the fourth gives a clue to why these changes might have occurred.

4. Under increased stress, group members show more behavior which tends to reduce interpersonal tension and friction and less behavior which might lead to increased disharmony. They become less argumentative and aggressive, and more cooperative and friendly. Under external stress and increasing anxiety, group members may well perceive the group as a source of security and, therefore, try to maintain their position in it and avoid rejection by being more cooperative and friendly.

4. Ruff, G. E., Levy, E. Z., & Thaler, V. H. Studies of isolation and confinement. Aerospace Med., 1959, 30, 599-604.

In confinement under simulated aerospace operational conditions, groups of five men spent five days in a compartment 17 feet long, 7 feet wide, and 6 feet high. The compartment's interior was carefully designed to minimize physical discomfort and monotony.

Method

Measures were selected to assess the behavior of the group as a whole, as well as of individuals.

Measures of group behavior included:

a. Direct observation, including diaries, tape recordings, and motion pictures.

b. Bales Interaction Analysis.

c. Ranking scale to determine attitudes toward other crew members -- traits such as "friendly," "confident," "patient."

d. Interpersonal projection test where subjects arranged photographs of crew members according to their appearance of being "relaxed," "upset," "angry," "sad," or "pleasant."

e. Draw-a-Group Test.

Measures of individual behavior included:

a. Psychiatric examinations by two psychiatrists before and after experiment.

b. Personality tests including the Rorschach, Thematic Apperception Test, Minnesota Multiphasic Personality Inventory, Blacky, Draw-a-Person, and Sentence Completion Test.

c. Intelligence tests.

d. Performance tests of vigilance, counting ability, and reaction time.

e. Bender-Gestalt.

Physiological measures included:

a. Electroencephalogram.

b. Electrocardiogram.

c. Skin resistance (occurring in the autonomic nervous system).

Biochemical measures included:

a. Urinary pepsinogen.

b. Adrenal steroids.

c. Sodium, chloride, and potassium levels.

d. Hippuric acid.

Measures of medical status included:

a. Recent flight physical examinations.

b. Hematology.

c. Urinalysis.

Results

1. Crew members who began with a positive attitude toward each other tended to maintain it throughout the experiment. Each group seemed to have a characteristic "personality." For example, the second crew, a group of volunteers, became highly involved in the mission. Their responses were vigorous and intense. The third group, mostly non-volunteers, accepted the experiment as a duty. They performed efficiently, but without the high spirits of the second crew.

2. Interest in food increased during confinement, and crews talked incessantly about food.

3. The personality tests revealed a trend toward regressive behavior, and there were signs of ego-impairment. On the other hand, subjects often appeared able to handle certain conflict areas more maturely and flexibly after the experiment than before it began.

4. The most common problem was feeling hostile toward fellow crew members. Anger was seldom expressed directly, but it often appeared as sarcasm, comments in diaries, or in the choice of stories and figures for projective tests.

5. Physiological and biochemical measures varied from day to day, but not in any consistent pattern. Blood and urine results remained within normal limits.

A second series of experiments examined how different individuals react to unusual situations. Since this series used experimental isolation, it is not included here.

5. Hagen, D. H. Crew interaction during a thirty-day simulated space flight. Preliminary study. Report 61-66, USAF School of Aerospace Medicine, Aerospace Medical Center, Brooks Air Force Base, Texas, June 1961.

Hagen studied interaction between two subjects who spent 30 days in a space-capsule simulator. The two subjects were chosen primarily because they were available; they were not screened. Both were career Air Force officers, college graduates, married, in their early thirties, and both had received commissions in the rigorous Aviation Cadet Program.

Method

The Bales Interaction Process Analysis was used to measure the subjects' behavior objectively during prescheduled observation periods.

All observations were made by a psychometrician. Reliability coefficients were obtained during joint observation periods in which both Hagen and the psychometrician scored behavior independently. There were two observation periods each day, from 0700 to 0800 hours, and from 2000 to 2100 hours. These were "ground control" periods when the subjects were relatively free to relax, sleep, or do as they wished. In all, there were 50 observation periods, 26 during the morning and 24 during the evening.

The two officers followed a precise schedule for work and rest. During work periods -- approximately 11 hours a day -- they performed complex, system-type psychomotor tasks.

Results

1. The subjects' adaptive mechanisms prevented overt conflict. Subjects were able to work together, and as if by unspoken agreement, found ways of avoiding behavior that might have forced them to abort the mission. They achieved this harmony in two ways: (a) they minimized physical interaction during their free time, and (b) they limited their verbal communication to certain restricted areas.

2. The relationship between the two men was formal and brittle. They did not solicit each other's opinions. The most obvious interpretation is that they increased their psychic distance from each other and lost sensitivity to each other's feelings and thoughts. This seemed to mirror the increase in covert hostility the subjects felt about each other during this time.

3. The subjects avoided possible disruptive conflict by keeping ut of each other's wa verbally as well as physically. By keeping most of their nteractions in the "socially polite" behavioral categories, they reduced the risk of sagreements or antagonisms.

Conclusion

The subjects used the confinement situation and their individual adaptive mechanisms to control conflicts arising from personality differences. Thus they were able to maintain their effectiveness as a crew and completed this mission successfully.

6. Altman, J. W., Smith, R. W., Meyers, Rheda L., McKenna, F. S., & Bryson, Sara. Psychological and social adjustment in a simulated shelter. Research Report, American Institute for Research, Pittsburgh, Pa., July 1961.

This study evaluated how shelter habitability depends on psychological and social factors. A simulated shelter was constructed to allow continuous auditory and visual monitoring of its occupant's reactions.

Method

A series of four experimental groups lived in the shelter. Each group consisted of 30 subjects -- men, women, and children. The first three groups stayed in the shelter for one week and the fourth group remained for two weeks.

The major experimental variables were temperature and the presence or absence of a trained and designated manager. Subjects were paid volunteers between the ages of seven to 72. They were confined to eight square feet, 58 cubic feet per person.

Results

1. Trained and designated managers improved the overall adjustment to shelter living and enhanced attitudes toward shelters, civil defense, and people in general.

2. Agitation and tension were greatest immediately after a group entered the shelter and just before they were to be released. Mild depression was common toward the middle of the confinement. Effective management minimized these effects.

3. Shelter adjustment seemed to be a fairly direct reflection of an individual's general pre-shelter adjustment pattern.

4. Strong individual loyalties and general esprit de corps grew rapidly.

5. Effective temperatures up to 85° F proved tolerable, but seemed close to the upper tolerance threshold.

7. Flinn, D. E., Monroe, J. T., Jr., Cramer, E. H., & Hagen, D. H. Observations in the SAM two-man space cabin simulator: IV. Behavioral factors in selection and performance. Aerospace Med., 1961, 32, 610-615.

Years of experience with submarines have demonstrated that selected volunteers can tolerate marked confinement, yet still perform effectively for prolonged periods. In the restrictive environment of the submarine, there are significant levels of interpersonal friction, monotony, and lowered morale and motivation. Despite these problems, performance generally remains high. However, the conditions are sufficiently different from other forms of confinement that conclusions cannot be generalized uncritically.

This study had three goals: (a) to observe patterns of behavior and identify disruptive emotional reactions, (b) to anticipate ways to minimize stresses, and (c) to select individuals who are better able to cope with the stresses inherent in the confined situation.

Method

The two subjects had four hours of standard psychiatric interviews with two observers. The observers independently rated basic personality variables such as dependency, dominance, hostility, self-concept, emotional stability, impulsivity, and social adjustment. A pre-confinement battery of psychological tests included the Rorschach, Wechsler Intelligence Scale, and Thematic Apperception Test. After the experiment, the Rorschach and another form of the Wechsler were repeated. Observers monitored subjects continually on closed-circuit television and scored their behavior with the Bales Interpersonal Process Analysis twice daily for a period of one hour. Each subject was asked to keep a diary.

Postflight observations were obtained in unstructured interviews where subjects were asked to discuss their subjective experience during the flight. They were specifically asked to amplify the comments which they made in their diaries.

Results

In general, the subjects' morale and motivation remained surprisingly high during the prolonged simulated flights. The subjects reported very little boredom, despite the seeming monotony of their routine. They did not show any emotional changes pronounced enough to interfere significantly with interpersonal accord and performance. Although they suffered occasional auditory illusions, they gave no sign of gross perceptual aberrations.

In each flight, some feelings of resentment arose from the subjects' differing behavioral characteristics. Neither of the subjects was openly designated as leader, and the subjects were left to structure their duties in any way they saw fit. This lack of structuring also led to some covert antagonism, which was confirmed in post-flight debriefings and diaries. The success of the mission mattered enough to the subjects that they consciously refrained from any behavior which might have had a disruptive effect, so they were able to continue working together without open friction.

Subjects refrained from expressing much negative feeling for fear of disrupting their relationship. Much of the negative feeling that was expressed was displaced and directed toward monitoring personnel outside the chamber.

The results indicate that subjects with rather marked personality differences can work effectively under the conditions imposed by the two-man space-cabin simulator for up to 30 days and, with adequate motivation, can maintain a satisfactory working relationship.

8. Cleveland, S. E., Boyd, Ina, Sheer, Diana, & Reitman, E. E. Effects of fallout shelter confinement on family adjustment. Arch. gen. Psychiat., 1963, 8, 38-46.

A middle-class family of four, two adults and two teen-age boys, spent two weeks in an underground shelter, under conditions of simulated nuclear attack.

Method

The family was evaluated with psychiatric interviews, psychological tests, and social-case workups just before they entered the shelter and immediately after they left it. Individual daily diaries and daily self-administration of an adjective check list provided day-to-day measurements of mood and family interaction in the shelter.

Results

Intellectual performance and personality showed no significant changes after confinement, although the subjects' moods were more irritable and depressed.

As a by-product, this experiment increased family unity.

C. Performance under Confinement Conditions

1. Jones, M. B. & Goodson, J. E. The effect of boredom on suggestibility. Aerospace Med., 1959, 30, 716-721.

Problem and Method

An experimental group of 24 naval aviation cadets was deprived of all social contact for approximately eight hours, then tested individually for suggestibility by the Hull body-sway technique, arm levitation, and leg catalepsy. Then they were compared with a control group of 24 cadets who had been taking routine psychological tests for the same period of time.

Results

1. The experimental subjects were more suggestible than the control group.

2. With arm levitation, which is a less sensitive measure of suggestibility, the two groups did not differ.

3. The investigators considered the possibility that body sway might have been increased by muscular inactivity or special treatment, but they concluded that these effects could not account for the experimental group's greater suggestibility.

2. Hanna, T. D. & Gaito, J. Performance and habitability aspects of extended confinement in sealed cabins. Aerospace Med., 1960, 31, 399-406.

This study examined how six men's performance changed during seven days of confinement in a small area, at a simulated altitude of 10,000 feet, and with an oxygen concentration equivalent to 55 percent at sea level. Each man had about 75 cubic feet of space.

Method

The measures of performance included:

a. Keeping three dial pointers at their null points.

b. Reacting to visual warning indicators.

c. Attending to details of a spoken prose passage and making inferences beyond the material presented.

d. Doing arithmetical reasoning.

e. Learning to associate single or multiple alternatives in an alternatives test.

f. Finding multiple solutions in a test of intellectual flexibility.

g. Discriminating weights.

h. Estimating time at 90-second time intervals.

The subjects worked shifts in pairs for four hours on duty, eight hours off duty, and then another four hours on duty, for every 24-hour period. The leisure tasks were performed three times a day, at 0400, 1200, and 2000 hours. The subjects worked in pairs, with each man administering, scoring, and timing his partner's performance.

Results

1. Subjects' intellectual functions did not deteriorate over a seven-day period even though the environmental conditions were not optimum.

2. With complex tasks which seemed inherently motivating, performance was as effective on the seventh day of confinement as on the first day.

3. The variable performance on psychomotor tasks probably represents symptoms of boredom. Apparently longer confinements tend to magnify the effects of any deviation from optimum conditions.

4. The author suggested that simple, routine tasks should be supplemented with more complex tasks which require higher-level behavior.

3. Burns, N. M. & Gifford, E. C. Environmental requirements of sealed cabins for space and orbital flights. A second study. Part II: Effects of long term confinement on performance. Report NAMC-ACEL 414, Air Crew Equipment Lab., U. S. Naval Air Materiel Center, Philadelphia, Pa., March 1961.

This study describes how long-term confinement affects operators' performance in simulated space vehicles. First it outlines some of the more basic behavioral variables which one might expect confinement to modify. Three broad behavior areas were investigated systematically: rigidity, suggestibility, and time estimation. In addition, Burns attempted to gather some data about group cohesiveness and vigilance.

Method

The subjects were six enlisted men between the ages of 18 and 29. During eight days of confinement, they took four tests repeatedly: time estimation, multiple solutions, key tapping, and the battleship game.

Results

1. Performance deteriorated rapidly on tasks where the operator had to do routine jobs which seemed unimportant.

2. However, when operators became ego-involved and had feedback of results, they continued to perform effectively over long periods of time.

3. Compared to a control group, the subjects consistently overestimated the passage of time: the longer they were confined, the more they overestimated.

4. Integrated interpersonal behavior tended to disintegrate as confinement lengthened: the longer subjects were confined together, the less well they tended to cooperate and get along together.

4. Ormiston, D. W. & Finkelstein, Beatrice. The effects of confinement on intellectual and perceptual functioning. ASD Technical Report 61-577, Aerospace Medical Lab., Aeronautical Systems Div., Air Force Systems Command, Wright-Patterson Air Force Base, Ohio, October 1961.

This study measured how selected intellectual, perceptual, and psychomotor behaviors change when an individual is confined in an escape capsule for 48 hours. It also evaluated a diet proposed for orbital flights, to see how acceptable it was and how it affected performance.

Method

Twenty Air Force officers volunteered as subjects. They were split into two equal groups -- confined and unconfined -- then further subdivided so each group had five subjects for the test diet and five for the control diet. Each subject worked on a variety of tasks: arithmetic, memory for digits, confusion sentences, nonsense syllables, verbal analogies, same-opposite word meanings, logical reasoning, embedded figures, form discrimination, aerial reconnaissance, and dual compensatory tracking. Whenever the subjects were not working on these tasks, they had to monitor warning lights. Food acceptance was measured by having the subjects rate the foods in a questionnaire.

Confined subjects had to stay in the capsule for 48 hours; unconfined subjects stayed in the capsule only while working. A normal sleep period began at 2230 and ended at 0700 hours. A low-residue diet, given for three days prior to the experimental period, adequately reduced the need to defecate. The test diet was cold food in the forms of liquids, semisolids, and bite-size solids. This diet had fewer calories than the control diet, but it was nutritionally adequate.

Results

The confined and unconfined groups did not differ significantly on any of the performance measures. However, the test diet rated significantly less acceptable than the control diet. Also subjects on the test diet showed a small loss in mean weight, while the control subjects showed a small gain in mean weight.

Conclusions

The authors correlated these results with other findings in the literature and conclude that:

a. Close confinement for 48 hours apparently has no appreciable effect on intellectual functioning, as measured by items similar to those of standard intelligence tests.

b. Subjects readily maintain their perceptual speed and accuracy, and form discrimination under confinement conditions.

c. Confinement does not seem to degrade warning-light monitoring.

d. Confinement generally makes the subject irritable enough to show undesirable behavior he would normally keep under control.

e. Confined subjects are not so likely to behave bizarrely as sensorily deprived subjects, nor is their performance so likely to deteriorate. However, they may sometimes experience intense fear or panic.

f. Temporarily living on foods that are less acceptable than conventional foods will probably not have any appreciable adverse effects on performance.

g. Whether confinement affects food acceptance depends on the variety, texture, temperature, packaging, and presentation of the food, as well as on social influences.

h. The best food regimen would include warm foods, varying in texture and consistency, and allow subjects to choose foods they like.

5. McGrath, J. J., Maag, C. H., Hatcher, J. F., & Breyer, W. P. Human factor problems in anti-submarine warfare. Human performance during five days confinement. Technical Memorandum 206-14, Human Factors Research, Inc., Los Angeles, Calif., January 1962.

This study describes how two men performed during 120 hours of continuous confinement in a low-pressure, pure-oxygen atmosphere.

Method

Two men were confined in a six feet square and six feet high cabin. One man, dressed in a full pressure suit, ate a low-bulk diet during the confinement period. The other, wearing standard Navy flight clothes, had a normal diet of Navy food.

After the men submitted to a pre-oxygenation period, the chamber was flooded with approximately 100 percent oxygen and brought to a pressure of 3.6 psi (simulating an altitude of 34,000 feet) for the entire 120-hour confinement period.

The subjects worked alternately for five-hour periods. Their performance was measured with five tests:

a. Vigilance Task -- watching a light in a one-inch-square section of a port and detecting when its brightness increased.

b. Memory-Span Test -- reproducing a series of digits immediately.

c. Attention Test -- listening to successive series of three digits and responding when the first digit in the series was lowest and the third digit highest, etc.

d. Time-Perception Task -- judging intervals of time.

e. Object-Identification Test -- looking at series of slides showing progressively more detailed line drawings of common objects and trying to guess the objects. First slide showed very few details; each slide gave greater detail until, finally, the seventh slide showed the complete object.

Results

1. Detection performance keeps deteriorating as long as subjects remain in an essentially unchanging environment. However, data were not sufficient to show how confinement affects detections.

2. Confinement apparently did not affect memory span, although performance on the attention test seemed to deteriorate during the session. One subject showed decrements on the time-perception and object-identification tests, but the other did not.

6. Chambers, R. M. Problems and research in space psychology. Report NADC-MA-6145, Aviation Medical Acceleration Lab., U. S. Naval Air Development Center, Johnsville, Pa., April 1962.

During long confinement, perceptual and motor skills show several characteristic kinds of degradation. These may be regarded as psychological mechanisms or merely as descriptions of errors which occur during prolonged confinement. Chambers lists some ways in which confinement stress may degrade skills:

"1. Omission of portions of simple tasks, or of parts of complex perceptual-motor tasks. These occur especially during overload when the subject may not process all of the stimulus information, such as the inputs necessary to perform the secondary parts of the task at the originally achieved level of proficiency.

"2. Approximation. The subject's behavior becomes less accurate, although the task does not increase in difficulty level. His responses become less precise, but minimally adequate to meet the required criterion of proficiency.

"3. Increases in latency of response to discrimination stimuli. Also, there may be large changes in timing of component response sequences, or gross misjudgments on the passage of time.

"4. Error and/or escape from the performance task. The subject's error amplitude and error frequency distributions increase rapidly and, in some situations, the subject may stop responding altogether as through drowsiness or refusal to continue performing the task.

"5. Queuing. A kind of delaying of the response during peak loads, and then catching up on the skill during lulls.

"6. Lapses. The psychomotor response appears to phase on and off target, showing a very irregular rate of response. A marked variability in performance is shown.

"7. Stereotyping of responses and movements, regardless of the stimulus situation. All of the stimuli appear to have an apparent equivalence to the subject during prolonged confinement if there is excessive redundancy. There is a loss of flexibility of set, and a dysfunction of discrimination and response. . .

"8. Filtering. A systematic filtering or omission of certain categories of stimulation and responding, according to some subjective priority scheme. Frequently, this appears to occur when there is a marked increase in stresses which are incidental to the primary purpose of the confinement."

There are also several characteristic types of errors affecting complex intellectual tasks during prolonged confinement. While these errors do not measure degradation of any particular higher mental ability, they seem to be promising indications that general intelligence is impaired temporarily. Chambers also lists these errors:

"1. Lapses, or increasing unevenness and irregularity of performing the task.

"2. Performance oscillations.

"3. Increase in error amplitude.

"4. Falling off in proficiency on some parts of a task while maintaining proficiency on other parts.

"5. Changes in phasing and/or timing task components.

"6. Reduction or cessation in performance output of some task components.

"7. Inadvertent control inputs.

"8. Failure to detect and respond to changes in the stimulus field.

"9. Errors in retrieving, integrating, storing and processing information.

"10. Sudden changes in the rate or frequency of performance such as sudden initiation of performance non-essential to the task.

"11. Response lags.

"12. Initiation of performance which is non-essential to the primary task.

"13. Overcontrolling or undercontrolling, as during a transitional phase.

"14. Perceived disintegration of the perceptual field or display.

"15. Dissociation of corrective response from appropriate control unit.

"16. Loss of proficiency due to fixation-block-confusion.

"All of the above error performances are highly variable, very difficult to measure, and extremely sensitive to subtle changes in the environment. Indicants based on these are useful for studies in higher mental abilities, but due largely to insufficient physiological instrumentation and measurement techniques, their relationships to other psychological and physiological events are unclear."

7. Alluisi, E. A., Hall, T. J., & Chiles, W. D. Group performance during four hour periods of confinement. Technical Documentary Report MRL-TDR 62-70, Aerospace Medical Research Laboratories, Wright-Patterson Air Force Base, Ohio, June 1962.

This research was undertaken principally to find the reliabilities of several small groups -- individuals and crews -- performing tasks similar to those in complex aerospace systems.

Method

In this study, subjects worked as crew members while confined in a mock-up of an advanced-system crew compartment. Twenty-five subjects were divided into five five-man groups and trained for three days, then tested for four-hour periods on each of four days.

The psychological functioning of both individuals and groups was measured with a battery of six performance tests. These tasks sampled fundamental abilities such as mental computation, pattern discrimination, monitoring, and vigilance; in addition, the two group-performance tasks required crew members to exchange information, cooperate and coordinate with each other. The tasks were displayed on identical 11-x-28-inch panels.

Results

The data obtained in this study confirmed that it is feasible to measure group performance quantitatively with crew tasks that require crew interaction, exchanges of information, cooperation, and coordination.

All six tests and all performance criteria used with the tests were reliable enough for future use.

8. Alluisi, E. A., Hall, T. J., Hawkes, G. R., & Chiles, W. D. Human group performance during confinement. Final Report ER 6024, Human Factors Research Dept., Lockheed-Georgia Co., Marietta, Ga., November 1962.

This research deals with individual men and crews of men who were confined for prolonged periods (15 to 30 days) to a restrictive environment (1100 cubic feet) that demanded considerable activity. The study compared a work-rest schedule of four hours on duty and two hours off duty to a schedule of four hours on and four hours off duty.

Method

Six Air Force Academy cadets were confined to a simulated advanced-system crew compartment for 15 days on a 4 - 2 work-rest schedule, and two five-man crews of Air Force pilots were confined for 30 days on a 4 - 4 schedule. With the six-man crew on the 4 - 2 schedule, four work stations were operated continuously for the 15 days. The two five-man crews operated five work stations, alternating four-hour work shifts continuously for 30 days.

While on duty, the operators were tested with a battery of six performance tasks, including auditory vigilance, warning-light monitoring, probability monitoring, arithmetic computation, code-lock solving, and target identification. In the last two tasks, groups had to interact in exchanges of information, cooperation, and temporal coordination. Their data were also compared with results of another Alluisi study where comparable tasks were performed under similar conditions for 15 days on a 4 - 2 work-rest schedule.

Results

1. A relative minimum of selection suffices to identify highly motivated subjects who can maintain acceptable performance levels on a 4 - 2 schedule for at least two weeks and probably for as long as a month.

2. However, all crew members maintained their performance better on the 4 - 4 duty schedule. They can probably maintain this schedule for 60 to 90 days without decrements in performance.

3. The 4 - 4 schedule permits a "safety factor" -- crew members can make up for illness or other loss of man-hours by following a 4 - 2 schedule when necessary.

4. The 4 - 4 work-rest schedule is recommended as feasible where men must stay highly alert around the clock for moderately long intervals.

9. Adams, O. S. & Chiles, W. D. Prolonged human performance as a function of the work-rest cycle. Aerospace Med., 1963, 34, 132-138.

This study investigated the feasibility of a 4 - 2 duty schedule in operating advanced aerospace systems.

Method

Two combat-ready crews -- one five-man crew and one six-man crew -- were confined for 360 hours (or 15 days) in a simulated advanced-system crew compartment. They were tested separately on an around-the-clock schedule of four hours on duty and t[illegible]urs off duty, with a battery of five performance tasks (used by Alluisi in the study above) and four physiological measures (skin resistance, skin temperature, heart rate, and respiration rate).

Results

1. It proved relatively easy to select highly motivated crews which could work effectively for at least two weeks using a 4 - 2 work-rest schedule.

2. The more highly motivated a subject was, the less adverse effect the test conditions had on him.

3. Seven of the 11 subjects showed significant improvement on a learning task.

4. There was a decrease in level of autonomic activity (increase in skin resistance and decrease in heart rate).

5. A majority of the subjects said they could have continued the test for another 15 days if necessary.

10. Alluisi, E. A., Chiles, W. D., & Hall, T. J. Combined effects of sleep loss and demanding work-rest schedules on crew performance. AMRL TDR 64-63, Lockheed Aircraft Corp., Marietta, Ga., December 1962 - March 1964.

This study compared two work schedules -- the 4 - 4 and the 4 - 2 -- in terms of crew operation in an advanced aerospace system.

Method

Subjects were organized into two five-man crews who worked alternating shifts on a 4 - 4 duty schedule during a 12-day confinement period. The performance measures were the same as those used in the two studies above.

During the middle two days of the 12-day confinement period, the crews following the 4 - 4 work-rest schedule were assigned extra work so each man had to remain awake for a 44-hour period.

Results

Combining the results of all three studies shows that:

a. Performance is generally more effective on the 4 - 4 schedule than on the 4 - 2 schedule.

b. The stress of losing sleep generally produces greater performance decrements with the 4 - 2 schedule than with the 4 - 4 schedule.

c. The 4 - 2 schedule is not recommended when high-level performance is critically important and there may be emergency periods when the men will lose sleep.

11. Patton, R. M. Behavioral testing during a 7-day confinement: The information processing task. NASA Technical Note D-1973, Ames Research Center, Moffett Field, Calif., December 1963.

This study investigated how well two subjects, confined for seven days in a simulated space capsule, performed an information-processing task.

Method

Two subjects ("S" and "R") were confined for seven days in a mocked-up space capsule that had a usable volume of 123 cubic feet. The subjects, alternating shifts, had a 4 - 4 duty cycle. One of the physiological and behavioral measures required the subject to act as an information processor. His task was locating and marking certain designated letters among an array of letters. Task complexity was manipulated by varying the number of designated letters and the ratio of designated to irrelevant letters within the array. The subjects performed this task once during each duty period.

Results

1. There were two criteria of performance on the information-processing task: speed (letters processed per minute) and errors (errors per page). Over the course of confinement, both subjects showed faster speed scores; but subject R made less errors, while subject S showed no significant change Subject R's error score was related to time of day: fewest errors during his night shift and most errors during his day shift. Confinement did not seem to change this cycle. Subject S's error score was not related to time of day, although his speed score was: fastest performance during the early evening and slowest later at night. Confinement exaggerated this difference. Interestingly, subject R's speed score did not depend on time of day.

2. Although task complexity had a marked effect on speed and error scores, the results did not confirm the hypothesis that, under unfavorable conditions (non-preferred shifts), performance would be degraded more with relatively complex tasks than with simple tasks.

3. Task performance was maintained at what appeared to be a reasonably high level throughout the seven-day confinement.

Conclusion

Under the conditions of this study, subjects can maintain proficiency in an information-processing task in a small capsule.

12. Patton, R. M. & Randle, R. J., Jr. Behavioral testing during a seven-day confinement: The pattern discrimination task. NASA Technical Note D-1974, Ames Research Center, Moffett Field, Calif., December 1963.

This study investigated how well subjects discriminated patterns during seven days' confinement in a simulated space capsule.

Method

Two subjects ("S" and "R") were confined in a mocked-up space capsule for seven days, and their performance on a pattern-discrimination task was evaluated. The subjects, alternating shifts, had a 4 - 4 duty cycle. The patterns were three to seven lighted elements in a 6 x 6 matrix of lamps, presented at the beginning and again at the end of the on-duty shift. Each subject had to discriminate or match approximately 150 patterns during each session. Every comparison pattern was rotated 180 degrees from the position of the standard. Performances were compared for the two sessions within a shift, as well as between shifts, and between days. Quality of performance was measured quantitatively as the percent of pattern discriminations that were incorrect.

Results

1. Subject S's performance varied with the time of day. He performed best on the evening shifts, next best on night shifts, and poorest on day shifts. This difference was largest at the beginning of confinement, and it disappeared toward the end. Subject R's performance did not vary significantly with time of day.

2. Comparing data from the beginning and end of each shift, subject R always had a uniform degradation during the shift. Subject S improved during the shift on the first days of confinement, but showed deterioration within the shifts at the end of confinement.

Conclusions

1. Results did not confirm the hypothesis that difficult discriminations deteriorate more than easy discriminations under unfavorable conditions of day, shift, or session.

2. The authors conclude that the subjects maintained their task performance at a reasonably high level throughout the seven-day confinement. This result indicates that, under the conditions of this study, subjects can maintain their pattern discrimination efficiency in a small capsule.

13. Hicks, S. A. The effects of four hours confinement in mobile armored personnel carriers on selected combat relevant skills: A pilot study. Technical Memorandum 3-60, U. S. Army Human Engineering Laboratories, Aberdeen Proving Ground, Md., March 1960.

This study determined the way four hours' confinement in a moving armored personnel carrier affects performance on psychomotor tasks related to basic infantry skills.

Method

Before and after confinement, 30 enlisted men took tests -- rail walking, obstructed run, rifle fire, and grenade throwing -- designed to estimate their stamina, response time, gross motor coordination, arm steadiness, equilibrium, and eye-arm coordination.

Results

1. The four-hour confinement period produced losses in all areas, with a significant loss in firing accuracy and significant impairment of equilibrium.

2. Perhaps the most important factor degrading performance was the feeling of nausea that a number of subjects reported.

3. The most frequent complaint was that the limited space caused cramping and, consequently, loss of circulation in the lower part of the body.

14. Hicks, S. A. The effects of eight hours confinement in mobile armored personnel carriers on selected combat relevant skills: Study II. Technical Memorandum 17-60, U. S. Army Human Engineering Laboratories, Aberdeen Proving Ground, Md., November 1960.

This study measured several kinds of psychomotor performance that are related to basic infantry skills, after eight hours' confinement in a moving armored personnel carrier.

Method

Each of the subjects -- 48 enlisted men -- did two of the four experimental tasks: rail walking, an obstructed run, rifle firing, and grenade throwing, which estimated their equilibrium, stamina, and gross motor coordination, hand-arm steadiness and eye-arm coordination. Data were collected before and after confinement.

Results

1. There was a significant loss in stamina and gross-motor coordination.

2. Equilibrium was significantly impaired.

3. Subjects reported decidedly more nausea and cramping than in the previous study.

15. Hicks, S. A. The effects of twelve hours confinement in static armored personnel carriers on selected combat relevant skills: Study III. Technical Memorandum 1-61, U. S. Army Human Engineering Laboratories, Aberdeen Proving Ground, Md., February 1961.

This is the third in a series of studies investigating how prolonged confinement in armored personnel carriers (APCs) affects performance on various combat-relevant tasks. In this study, the subjects were confined in stationary APCs for 12 hours. Because the vehicle was stationary, noise and gross vehicle movement could not affect post-confinement performance. Secondarily, this study attempted to determine the extent to which subjects' activity levels contribute to the observed performance decrements.

Method

Before and after confinement, 40 enlisted men took tests of rail walking, obstructed running, grenade throwing, and rifle firing. During confinement one group of men was required to perform a series of tasks primarily to keep busy. These tasks were map reading, watch keeping, telephone operating, log keeping, and counting. The other groups were not assigned specific tasks during confinement.

Results

1. After confinement, the subjects showed significant loss of equilibrium, stamina, locomotor coordination, and grenade-throwing accuracy. There was no change in rifle-firing accuracy.

2. The observed decrements may arise mainly because the size and configuration of the vehicle cause cramping, rather than because of motion, noise, vibration, etc.

3. When a group of men are confined in an APC for 12 hours, the interior of the vehicle becomes hot, damp, smelly, cluttered, and dirty -- even in moderate temperatures with the engine off, the crew cannot withstand such a hostile environment indefinitely.

16. Hicks, S. A. The effects of twelve hours confinement in mobile armored personnel carriers on selected combat relevant skills: Study IV. Technical Memorandum 2-61, U. S. Army Human Engineering Laboratories, Aberdeen Proving Ground, Md., May 1961.

This investigation is the fourth in a series investigating how prolonged confinement in APCs affects performance on various combat-relevant tasks. In this study, subjects were confined in moving APCs for 12 hours.

Method

Before and after 12 hours' confinement, 40 enlisted men took tests of stamina, eye-arm coordination, locomotor coordination, equilibrium, and hand-arm steadiness.

Results

The results indicated that 12 hours' confinement in maneuvering APCs affected stamina and/or locomotor coordination. Hicks attributes the discrepancy between these results and the results of the previous studies to reduced motivation or faulty experimental procedure, or both.

17. Hicks, S. A. The effects of twenty-four hours confinement in mobile armored personnel carriers on selected combat relevant skills: Study V. Technical Memorandum 23-61, U. S. Army Human Engineering Laboratories, Aberdeen Proving Ground, Md., November 1961.

This investigation is the fifth in a series evaluating how sustained confinement in armored personnel carriers (APCs) affects performance on various combat-relevant tasks. It measured how performance changes after 24 hours' confinement in mobile APCs.

Method

Before and after 24 hours' confinement, 44 enlisted men took tests of stamina, eye-arm coordination, locomotor coordination, equilibrium, and hand-arm steadiness.

Results

1. Approximately half the subjects performed as well after confinement as before it.

2. The 24-hour confinement period produced a statistically significant loss in eye-arm coordination and hand-arm steadiness.

3. Twenty-three subjects did not complete the study. In analyzing the results, Hicks points out that this may have been an important factor, because it suggests that some selection process was in operation during the experiment. He hypothesizes that individuals who were extremely sensitive to the vehicle environment may have tended to disqualify themselves, while individuals who could adjust to the harsh environment completed the experiment and performed at a near-normal level. Because so many subjects dropped out, the subjects who were left in the vehicle had more room to move around and could select relatively comfortable positions for sleeping and relaxing.

4. Many subjects who completed the experiment volunteered to undergo tests lasting even longer. Their primary reasons were:

a. Finding the extent of their endurance.

b. Determining their performance decrement over longer periods of time.

c. Competing with squad members.

18. Hicks, S. A. The effects of twenty-four hours confinement in mobile armored personnel carriers on selected combat relevant skills: A follow up. Technical Memorandum 7-62, U. S. Army Human Engineering Laboratories, Aberdeen Proving Ground, Md., June 1962.

This investigation studied how confining subjects in maneuvering armored personnel carriers for 24 hours affects the performance of combat-relevant tasks.

Method

Before and after confinement, 44 enlisted men took tests of stamina, eye-arm coordination, locomotor coordination, equilibrium, and hand-arm steadiness.

Results

1. The 24-hour confinement period produced statistically significant losses in all areas except eye-arm coordination (grenade-throwing accuracy).

2. At the end of the confinement period, the men's duffel bags and other equipment obstructed exit from the vehicle so much that it once took a squad approximately three minutes to dismount. The equipment also made good housekeeping virtually impossible. After 24 hours, the floors of the vehicle were cluttered with wasted rations, ration cans, and broken relief bags that complicated an already overwhelming and nauseous odor.

3. Because of the terrain over which these sessions were run, water collected in the bilges of the vehicles. Stowed equipment became soaked during normal maneuvering. A related problem is that water vapor collected on the vehicle's interior. During the periods of maximum condensation (usually from 2200 to 0600 hours), the occupants found it difficult to rest on the sidewalls, because clothing became wet and uncomfortable. Water collected on the ceiling and dripped down, wetting clothing and blankets. Arms and equipment tended to rust with continued exposure. In addition, the commander's vision blocks fogged up.

19. Hicks, S. A. The effects of repeated confinement on the performance of men in a hot-wet climate. Technical Memorandum 7-63, U. S. Army Human Engineering Laboratories, Aberdeen Proving Ground, Md., January 1963.

This investigation is the seventh in a series evaluating how prolonged confinement in armored personnel carriers affects performance of various combat-relevant tasks. In this study, a single group of subjects was confined repeatedly in a hot-wet environment (summer in Panama). All subjects had first been acclimatized to heat.

Method

Eleven volunteer enlisted men were confined on alternate days, for a total of 16 confinement sessions. The four different treatment periods used were: six hours open hatch, mobile; four hours closed hatch, mobile; six hours closed hatch, mobile; six hours closed hatch, static. Before and after confinement, the subjects took tests of choice reaction time, hand steadiness, equilibrium, and 220-yard running speed.

The subjects took one of the four performance tests at the end of each confinement session. All mobile-treatment conditions were driven on an unimproved dirt road. During the four static periods, the vehicle was parked in an open field without overhead cover.

An observer always rode with the subjects to watch them and collect physiological data, as well as to note temperatures and humidities in the vehicle.

Results

1. Repeated confinement in a hot-wet environment produces:

   a. Significant impairment of hand steadiness.

   b. Significant impairment of running speed.

   c. Significant decrement in equilibrium.

   d. No effect on three-alternative choice reaction times.

2. With each criterion measure, the decrement was largest after the initial exposure to the treatment variable. Making the environment more severe, by increasing confinement time and/or decreasing ventilation, did not produce any larger performance decrements.

20. Hicks, S. A. The effects of repeated confinement on the performance of men in a temperate environment. Technical Memorandum 11-64, U. S. Army Human Engineering Laboratories, Aberdeen Proving Ground, Md., August 1964.

This investigation is the eighth in a series designed to determine how confinement in armored personnel carriers affects performance of various combat-relevant tasks. The present study examined the effects of confining a single group of subjects in a mobile carrier repeatedly, for 12-hour periods on each of five successive days.

Method

Ninety enlisted men were divided into three groups of 30 men each. After practice trials to stabilize their performance, they took tests of equilibrium, stamina, gross motor coordination, and marksmanship. Their scores on the final practice trial comprised the base line for all comparisons. After each 12-hour confinement period, subjects were taken to the test-course areas immediately and given the post-confinement tests.

Results

1. There were statistically significant losses in all areas after the initial confinement period.

2. Subsequent confinements showed progressively smaller decrements until, after the final (fifth) confinement, subjects performed at the pre-confinement level.

Conclusion

Subjects adapt during repeated confinements. After subjects have experienced several confinements, further confinements do not degrade their performance.

21. Hicks, S. A. The effects of confinement on the performance of combat relevant skills: Summary report. Technical Memorandum 16-64, U. S. Army Human Engineering Laboratories, Aberdeen Proving Ground, Md., December 1964.

This report summarizes the extended research program investigating how long troops can withstand the adverse environmental conditions of long confinement in armored personnel carriers (APCs), while still maintaining their combat efficiency.

The ultimate goals of this program were:

a. Determining how long-term confinement in APCs affects the performance of infantry personnel.

b. Finding ways to maintain combat efficiency.

c. Gathering experimental data to guide the general design of future armored vehicles.

d. Determining the individual's psychological and physiological tolerance limits for confinement in tracked vehicles.

Method

Subjects included a total of 277 enlisted men.

Before and after confinement, they took tests of stamina, response time, gross motor coordination, arm steadiness, equilibrium, and eye-arm coordination. The tests included rail walking, the Stoelting Selective Reaction Time Test, the Stoelting Hand-Steadiness Test, an equilibrium test, an obstructed run, rifle firing, grenade throwing, and a 220-yard running course.

In the first study, 50 men were confined in a mobile APC for four hours.

In the second study, 48 men were confined in a mobile APC for eight hours.

In the third study, 40 men were confined in a static APC for 12 hours.

In the fourth study, 40 men were confined in a mobile APC for 12 hours.

In the fifth study, 44 men were confined in a mobile APC for 24 hours. Subjects were not required to remain in the confinement situation, and 23 subjects did not complete the study.

In the sixth study, 44 men underwent confinement for 24 hours in the mobile APC.

In the seventh study, 11 volunteers were confined for a total of 16 confinement sessions -- six hours open hatch, mobile; four hours, closed hatch, mobile; six hours, closed hatch, mobile; six hours, closed hatch, static -- in a hot, wet environment (summer in Panama).

In the eighth study, 90 men were confined in a mobile APC for 12-hour periods on each of five successive days.

Results

1. After confinement, most subjects were significantly poorer on all tests.

2. Highly motivated subjects had smaller decrements after confinement than subjects who were not highly motivated.

3. Repeated confinements produce adaptation: subjects show smaller decrements after each successive confinement.

4. Certain factors seem especially likely to cause performance decrements:

a. The vehicle configuration causes body cramping and, consequently, loss of lower-extremity circulation.

b. The backrest was uncomfortable because it pressed into the small of the back and kidney area.

c. The radio rack, mounted on the side wall of the vehicle, irritated the back and neck of the passenger who occupied that station.

d. Some 20 - 30 percent of personnel reported nausea during their first confinement.

e. Temperature and humidity rose steadily to 101° F and 94 percent relative humidity -- very uncomfortable -- even with the vehicle's engine off.

f. There were not enough equipment tie-downs and not enough space to stow equipment. The equipment interfered with entering and leaving the vehicle. Yet when personnel followed stowage procedures to keep their equipment off the floor, they could not locate it again easily.

g. Water vapor collected on the vehicle's interior surfaces, wetting clothing and rusting equipment.

Conclusions

1. Long-term confinement has relatively transient effects on the performance of infantry personnel, within the range studied.

2. It is not yet known whether recovery time is a constant or depends on length of confinement.

3. Confinement's detrimental effects on performance may be offset by repeated practice of the tasks to be performed and repeated exposure to the confinement situation before actual field deployment. Though there may be decrements after a single confinement, personnel adapt to repeated confinements, and performance decrements grow smaller.

4. The APC design deficiencies noted may be offset through careful application of the appropriate human engineering criteria.

22. Thor, D. H. & Crawford, M. L. J. Time perception during a two-week confinement: Influence of age, sex, IQ, and time of day. Acta Psychologica; 1964, 22, 78-84.

This study hypothesized that a group would maintain relatively accurate estimates of the time of day over an extended period without seeing clocks. The influence of age, sex, IQ, time of day, and days of confinement were also evaluated.

Method

Thirty men, women, and children, ages seven to 67, were confined in an experimental chamber for 304.6 hours with no way of telling time. The confinement area allowed eight square feet of floor space per person. There were no extrinsic cues (night and day) to time of day. Individuals estimated the time of day twice daily, at about 0900 and 2100 hours. The deviations of their estimates from true time, in minutes, were evaluated with mixed analyses of variance and trend tests.

Results

1. Morning estimates of time were slightly more accurate than evening estimates. But accuracy varied during the confinement. In the mid-confinement period, morning estimates became less accurate, while evening estimates became more accurate. In general, estimates of the time of day were earlier during mid-confinement than they were during the early or late confinement stages.

2. There were also age effects, but they mattered less than time of day or confinement stage.

3. IQ and sex did not affect time estimates.

Conclusions

1. A group of subjects can estimate the time of day relatively accurately (± 3 hours) over two weeks without natural or man-made cues.

2. Time of day affected time perception more than any other variable considered.

IV. PREDICTING ADJUSTMENT TO CONFINEMENT

1. Jones, M. B. Personal autonomy and confinement in the Naval service. Report 5, U. S. Naval School of Aviation Medicine, Pensacola, Fla., May 1956.

Jones tested the proposition that people who have trouble coping with authority -- both those who rebel against authority and those who cling to it -- are more prone to trouble in confinement.

Method

The Pensacola Z Scale was used to measure authoritarianism. It was administered to 176 men in training for submarine duty, as well as 407 "retrainees" imprisoned at the Naval Retraining Command. A glossary was provided to define various words and phrases in the Z scale in more commonplace terms.

Results

The differences between the two groups were significant well beyond the .001 level. On the General Classification Test, the groups did not differ significantly at the .05 level.

Conclusion

Jones suggests that, "The peculiar characteristic of the retrainee is not just that he is dependent but that he is dependent on his family. The overwhelming majority of retrainees go 'over the hill' and almost all of those who do, go home. The duty man of comparable GCT score may be equally dependent but on other authorities, particularly the Navy. Where this is the case, the duty man might re-enlist for much the same reasons that the retrainee goes 'over the hill'."

2. Eilbert, L. R. & Glaser, R. Differences between well and poorly adjusted groups in an isolated environment. J. appl. Psychol., 1959, 43, 271-274.

This study explores the possibility of finding variables to predict how an individual will adjust to isolated restrictive environments. More specifically, this is the first step in finding ways to select men who will adjust well, thus minimizing the number of personal adjustment problems on Arctic bases.

Eilbert and Glaser used supervisor's ratings of adjustment to select two groups of subjects -- 112 well adjusted and 83 poorly adjusted -- from a population of 648 airmen who, on the average, had been in the Arctic for seven months. Then they compared the two groups' performance on a battery of tests and survey instruments:

a. Biographical inventory

b. Self-appraisal blank

c. Incomplete Sentences Test

d. Medical symptoms list

e. Modified Taylor Manifest Anxiety Scale

f. Food aversion list

g. General information test

h. Peer nomination form

i. Air Force aptitude test scores

j. Job proficiency scores

k. Medical record data

Results

1. In general, the results suggest that individuals who adjust well to Arctic isolation:

a. Also adjust well to their military assignments elsewhere.

b. Describe themselves as conscientious, responsible individuals who accept authority.

c. Are rated well adjusted to the Arctic by peers as well as supervisors.

2. As a group the well adjusted airmen:

   a. Have a lower sick-call rate.

   b. Show higher job-proficiency test scores.

3. The poorly adjusted group was characterized by:

   a. Urban background.

   b. Relatively high socioeconomic background.

   c. A history of minor infractions of military regulations.

   d. More complaints.

   e. Fears of the Arctic.

   f. Less inclination to improve their job performance.

   g. Greater difficulties in interpersonal relationships.

The authors discuss the possibilities of generalizing these data to other types of isolated environments.

3. Weybrew, B. B., Molish, H. B., & Youniss, R. P. Prediction of adjustment to the Antarctic. Report 350, U. S. Naval Medical Research Laboratory, New London, Conn., April 1961.

This study examined how well psychometric and interview data predict how individuals will adjust to the Antarctic. It obtained predictive validities for several psychometric tests as well as trait ratings by teams of psychologists and psychiatrists, by relating them to criteria of adjustment to the Antarctic during the "wintering-over" period of 1957.

Method

One hundred nine men served as subjects. Fifty-five percent of the group were single, 38 percent married, and seven percent divorced or separated. The ages ranged from 18 to 56.

The potential predictor measures were:

a. Background information from the Standard Psychodiagnostic Record Booklet.

b. Shipley-Hartford Retreat Scale (useful for identifying certain kinds of psychopathology involving organicity).

c. Psychiatric ratings.

d. Group Rorschach.

e. Combined ratings by psychiatrists and psychologists.

f. Sports inventory.

g. Neurotic-symptom checklist.

The criteria of adjustment were:

a. Monthly health diary.

b. Line evaluation, or rating in overall performance of duty.

c. Attitude-study questionnaire.

d. Group-behavior description questionnaire.

The factor analytic method was used to analyze the data.

Results

The following characteristics seem to favor good adjustment to Antarctic conditions:

a. High intelligence-test scores.

b. Low interest in organized sports.

c. High rating in "ability to communicate."

d. Low rating in "overt hostility."

e. High rating in "ability to cope with aggression."

f. Less than a college education.

g. Single, rather than married, divorced, or separated.

h. Over 25 years of age.

i. Pre-service residence in the southern section of the United States.

4. Weybrew, B. B. The impact of isolation upon personnel. J. occupational Med., 1961, 3, 290-294.

This paper outlines the adjustment problems personnel face when living in isolation. It raises these specific questions:

a. What happens psychologically and physiologically to humans who live in relative isolation for prolonged periods of time?

b. What are the most efficient criteria for selecting individuals who are least liable to maladjustive breakdown under isolated conditions?

Anecdotal accounts by survivors of sea disasters suggest that (a) severe perceptual changes are the most probable effects of isolation; and (b) if isolation is extremely protracted, people may show antisocial behavior that they would be able to inhibit if stress were not so great.

One theory holds that "organismic integrity is a function of the level and perhaps variability of stimulus input." An extension of this theory states that the brain cannot function without a continuous arousal pattern generated and maintained in the reticular system and the reverberatory circuits connecting it, the hypothalamus, and the cortex. This arousal pattern, in turn, depends upon continuous sensory input.

Thus a relevant hypothesis emerges: that people are motivated to seek stimulation and that a situation which reduces or curtails sensory stimulation is harshly frustrating.

While external stimuli are not wholly eliminated in a submarine, the stimulus input is repetitive, invariant, and often monotonous.

Method

In a first study, a group of subjects in an isolated room was asked to watch a pointer moving in a circle (one revolution per minute). Each subject was to press a button for every 90 degrees of arc, or four times per minute. Subjects in the experimental group just kept pressing the button every 15 seconds, without knowing whether or not they pressed it at the right moment. The control subjects got feedback information telling them whether or not their timing was correct. One of the criterion measures was electrical skin conductance.

The major operational study of submarine confinement was completed in 1954. For 50 days, 23 men were confined in a sealed submarine in a high concentration of carbon dioxide (percentage not specified).

In another study, done aboard the TRITON submarine, habitual smokers were confined for 83 days without being allowed to smoke.

In yet another study done aboard the TRITON, 50 men completed a daily symptom checklist of 51 items during their 83-day confinement.

Results

1. The first study found that environmental feedback was an important factor in maintaining vigilance during a repetitious activity.

2. A high concentration of carbon dioxide did not degrade psychomotor or manipulative ability significantly, but it had other noteworthy effects:

a. Significantly lower personal motivation and group morale.

b. Greater interpersonal irritability.

c. More muscular tension, with consequent difficulties in sleeping.

d. More urinary carbonates and a shift in the electrolyte balance of the blood.

3. When habitual smokers could not smoke, they became more irritable and tense, and reported insomnia.

4. The daily symptom checklist showed:

a. Personal motivation and group morale declined after ten days' confinement.

b. Homesickness increased.

c. Morale was highest on Sundays, when the men were allowed more free time than usual.

d. Twenty-five percent of the subjects reported headache of undetermined origin on an average day.

e. Time perception became less accurate.

f. Three persons experienced anxiety reactions acute enough to demand medication.

5. The studies found five criteria for selecting men who will be confined in submarines:

a. His reasons for volunteering must be identified. For example, is the man volunteering because of a desire to aid in the defense of his country so he finds being on a submarine exciting, or is he volunteering because he fights with his wife and wants to get away from her.

b. He must meet standards of verbal, arithmetic, and mechanical aptitudes.

c. He must be motivated strongly enough (as measured by a special psychometric technique) to obtain the satisfactions available in submarine service.

d. His psychiatric status must be tested to delineate his major conflict areas, frequency and severity of his neurotic symptoms and main defense dynamisms.

e. His somatopsychological nature, in terms of reactivity and resiliency of his autonomic nervous system, must be evaluated.

When personnel are chosen with these five selection criteria, psychological and/or psychiatric failures in the submarine service are less than ten percent -- rather than an estimated attrition of 40 percent or more in an unselected population.

5. Epstein, E. N. Prediction of adjustment to prolonged submergence aboard a fleet ballistic missile submarine. II. Background variables. Vol. XXI, No. 15, Report 384, U. S. Naval Medical Research Laboratory, New London, Conn., July 1962.

This paper examined the possibility that age, education, early academic interest, marital status, geographic origin, family frictions, arrests, social attitude, time in fleet, and service record might predict adjustment to confinement during prolonged submergence.

Method

The subjects were two crews from a fleet ballistic-missile submarine (approximately 110 men per crew). The various criteria of adjustment -- attitudes toward Navy, attitudes toward fleet ballistic missile submarine service, rank, performance, military behavior, leadership appearance, and adaptability -- were obtained by factor analysis of 22 dimensions, largely ratings by officers and chief petty officers during prolonged submerged cruises. Four attitude-change scores were also used as adjustment criteria.

Results

1. The better-adjusted men tend to be over 21, second-class petty officers or higher, and married.

2. Men with over two years of service in fleet-type submarines and with broken service have more favorable attitudes toward the Navy.

3. There were virtually no significant relationships between the background variables and the attitude variables in this study.

Conclusion

The results suggest that relatively few of the background variables studied are systematically related to ability to adjust during prolonged submerged cruises in a fleet ballistic-missile mission.

6. Parker, J. W. Prediction of adjustment to prolonged submergence aboard a fleet ballistic missile submarine. III. Objective tests. Report 388, U. S. Naval Medical Research Laboratory, New London, Conn., October 1962.

This study attempted to evaluate the present test battery for selecting submariners by relating it to criteria of actual adjustment under operating conditions.

Method

The subjects were enlisted men from both crews of a fleet ballistic-missile submarine (approximately 110 men in each crew). Six predictors were used:

a. Personal Inventory Barometer.

b. Self-reported motivational questionnaire.

c. Navy Basic Test Battery.

d. Preliminary health questionnaire.

e. Submarine Attitude Questionnaire.

f. Level of aspiration, as tested by the Heinrich Two-Hand Coordination Test.

The study aimed, then, to validate these six criteria. It also examined peer ratings from samples of the crews.

Results

1. Various parts of the Navy Basic Test Battery are statistically significant predictors of adjustment.

2. Men with good personal adjustment scores on the Personal Inventory Barometer generally tended to adjust well during submerged cruises.

3. Scores on the Self-Motivational Questionnaire related negatively to success in adjusting.

4. The Submarine Attitude Questionnaire showed that subjects with favorable attitudes are those who get favorable ratings on personal traits.

5. Parker concluded that objective tests have limited value for predicting how men will adjust to duty on a fleet ballistic-missile submarine.

APPENDIX B

TECHNIQUES USED IN CONFINEMENT STUDIES

Some or all of the study techniques outlined below were used in most of the studies this survey incorporates. These techniques include questionnaires, subjective reports, psychological tests, psychomotor performance tests, intelligence tests, mental exercises, personality tests, and physiological measures. But the studies differed considerably in how they applied these techniques, and the various specific applications are listed below:

Questionnaires

adjective check lists
job proficiency
likes and dislikes
medical symptoms
neurotic symptoms

Subjective Reports

diaries
tape recordings
verbal comments in interviews

Psychological Tests

aptitude tests
depth perception
form discrimination
perceptual lag
target identification
time orientation
visual illusions (phi and autokinetic phenomena)
visual perception

Psychomotor Performance Tests

grenade throwing
Hull body sway
key tapping
monitoring
rail walking
reaction time
rifle firing
tracking
vigilance
visual motor tasks
weight discrimination

Intelligence Tests

Wechsler Adult Intelligence Scale
(whole or separate sub-tests)

Mental Exercises

computations
counting
picking numbers and letters from groups
remembering prose and poetry passages
word jumbles

Personality Tests

Allport-Vernon-Lindzey Study of Values
Bales Interaction Analysis
Bender-Gestalt
Blacky
Draw-A-Person
Edwards Personal Preference Schedule
Minnesota Multiphasic Personality Inventory
Rorschach
Sentence Completion Test
Taylor Manifest Anxiety Scale
Thematic Apperception Test

Physiological Measures

electrocardiogram
electroencephalogram
equilibrium
galvanic skin response
hemolysis
respiration rate
skin temperature
stamina
urinalysis

TABLE IB

Study Techniques

	Questionnaires	Psychiatric Interviews	Examiner Observation	Subject Report	Psychological Tests	Psychomotor Performance	Intelligence Tests	Mental Exercises	Personality Tests	Sensory Deprivation Techniques	Physiological Measures	Medical Exams
I. GENERAL PROBLEMS												
Burke et al. (11)	X		X	X								
Bexton et al. (9)			X	X			X	X		X		
Torrance (57)			X	X								
Freedman & Greenblatt (20)		X		X	X				X	X	X	
Ormiston (49, 50)				X	X	X			X			
Zubek et al. (62)	X			X	X	X	X			X		
II. PHYSICAL ENVIRONMENT												
Murray (48)			X	X		X	X			X		
IIIA. EFFECTS OF CONFINEMENT												
Weybrew (58)	X			X	X						X	
Tiller & Figur (56)											X	
Hanna (24, 25)											X	
IIIB. GROUP BEHAVIOR												
Kinsey (41)	X	X	X	X								
Lanzetta et al. (44)	X		X	X					X			
Lanzetta (43)			X	X					X			
Ruff et al. (54)	X	X	X	X			X	X	X		X	X
Hagen (23)			X						X			
Altman et al. (7)			X	X								
Flinn et al. (19)		X	X	X			X		X			
Cleveland et al. (14)		X		X					X			

IIIC. PERFORMANCE											
Jones & Goodson (40)					X				X		
Hanna & Gaito (26)					X		X				
Burns (12)					X	X					
Ormiston & Finkelstein (50)					X	X	X				
McGrath et al. (45)					X	X	X				
Alluisi et al. (3, 5, 6)			X			X		X		X	
Alluisi et al. (4)			X			X		X		X	
Patton (52, 53)					X						
Hicks (29-37)						X		X		X	
Thor & Crawford (55)					X				X		
IV. PREDICTING ADJUSTMENT											
Jones (39)											
Ellbert & Glaser (17)	X		X	X					X		
Weybrew et al. (60)	X	X	X	X					X		X
Weybrew (59)	X		X	X		X			X		X
Epstein (18)	X	X	X	X							X
Parker (51)	X						X				X

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11 SUPPLEMENTARY NOTES	12 SPONSORING MILITARY ACTIVITY

13 ABSTRACT

Field and laboratory confinement studies were reviewed to evaluate existing information and to identify areas where future research is needed.

The studies reviewed deal with confining two or more people in a restricted space for a prolonged period of time: particular attention was devoted to how such conditions degrade performance.

Few of the studies bear on the Army's chief interest in confinement: how men will perform during and after prolonged confinement in armored vehicles.

The review concludes by recommending ways to make future studies of confinement more directly relevant to the Army's interest.

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
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